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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b> A63B 37/02, 37/06, 37/12, B29C 39/18, 41/20, 43/18, 70/70, C08G 18/10, 18/32, 18/48	<b>A1</b>	<b>(11) International Publication Number:</b> WO 99/43394 <b>(43) International Publication Date:</b> 2 September 1999 (02.09.99)
<b>(21) International Application Number:</b> PCT/US99/04122 <b>(22) International Filing Date:</b> 25 February 1999 (25.02.99)  <b>(30) Priority Data:</b> 09/030,332 25 February 1998 (25.02.98) US 09/137,393 20 August 1998 (20.08.98) US  <b>(71) Applicant:</b> DUNLOP MAXFLI SPORTS CORPORATION [US/US]; 728 N. Pleasantburg Drive, Greenville, SC 29607 (US).  <b>(72) Inventors:</b> DEWANJEE, Pijush, K.; 1965 SunCrest Avenue, Oceanside, CA 92056 (US). TZIVANIS, Michael; 36 Tolpa Court, Chicopee, MA 01020 (US). KUTTAPPA, Sanjay, M.; 109 Creekview Drive, Clemson, SC 29631 (US). CALABRIA, John; 741 Shefwood Drive, Easley, SC 29642 (US). SITLER, Katherine; 503 Pine Terrace Drive, Seneca, SC 29678 (US). HOBBS, Thomas; 112 Foxdale Street, Toccoa, GA 30577 (US).  <b>(74) Agent:</b> LORUSSO, Anthony, M.; Lorusso & Loud, 440 Commercial Street, Boston, MA 02109 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> POLYURETHANE MATERIAL FOR TWO AND THREE PIECE GOLF BALLS AND METHOD  <b>(57) Abstract</b>  A novel composition useful for golf ball covers that comprises a blend of a diisocyanate/polyol polyurethane prepolymer with a curing agent comprising a blend of slow-reacting diamine with a fast-reacting diamine such as dimethylthio 2,4-toluenediamine and diethyl 2,4-toluenediamine, respectively, coupled with a novel manufacturing process and ball construction. A golf ball made with this invention exhibits the characteristic feel and playability of a balata cover with superior durability characteristics (cut and shear resistance) which exceed those of a balata or ionomer cover.		

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POLYURETHANE MATERIAL FOR TWO AND THREE PIECE GOLF BALLS  
AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

5 A claim of benefit is made to U.S. Application Serial  
Nos. 09/018,283, filed February 4, 1998, and 09/030,332, filed  
February 25, 1998, the contents of which are incorporated  
herein by reference. This is a continuation-in-part  
10 application of a regular utility application filed February  
25, 1998 which is a continuation-in-part application of a  
regular utility application filed February 4, 1998, the  
contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

15

1. FIELD OF THE INVENTION

This invention relates to novel chemical compositions for  
golf ball covers, construction and manufacturing processes  
that provide improved manufacturability and playability  
20 characteristics.

2. DESCRIPTION OF THE RELATED ART

Until the late 1960's, most golf balls were constructed  
with a thread wound core and a cover of compounds based on  
25 natural (balata and gutta percha) or synthetic  
transpolyisoprene. These golf balls have been and are still  
known to provide good flight distance. Additionally, due to  
the relative softness of the balata cover, skilled golfers can  
impart various spins on the ball in order to control the  
30 ball's flight path (e.g., "fade" or "draw") and "bite"  
characteristics upon landing on a green. "Fade" is the  
term used in golf to describe a particular golf ball flight  
path that is characterized by a curved or arched flight  
exhibited towards the latter portion of the flight path that  
35 veers off from the center line of the initial flight path to  
the right of a right-handed golfer. Upon contact with the  
ground, a ball hit with "fade" will stop in a relatively short

distance. "Fade" results from imparting clockwise sidespin on the golf ball.

"Draw" is the term used in golf to describe a particular golf ball flight path that is characterized by a curved or arched flight exhibited towards the latter portion of the flight path that veers off from the center line of the initial flight path to the left of a right-handed golfer. Upon contact with the ground, a ball hit with "draw", unlike a ball hit with "fade", will roll for a considerable distance until coming to rest. "Draw" results from imparting counter-clockwise sidespin on the golf ball.

"Bite" is the term used in golf to describe the effect of imparting a substantial amount of backspin to an approach shot to a green which causes the golf ball to stop abruptly upon contact with the green.

Another desirable feature of balata-based compounds is that they are readily adaptable to molding. These compounds therefor can be easily compression molded about a spherical core to produce golf balls.

Though possessing many desirable properties, there are substantial drawbacks to use of balata or transpolyisoprene-based compounds for golf ball covers. From a manufacturing standpoint, balata-type materials are expensive and the manufacturing procedures used are time consuming and labor-intensive, thereby adding to the material expense. From a player's perspective, golf balls constructed with balata-based covers are very susceptible to being cut from mishits and being sheared from "sharp" grooves on a club face. As a result, they have a relatively short life span.

In response to these drawbacks to balata-based golf ball covers, the golf ball manufacturing industry has shifted to the use of synthetic thermoplastic materials, most notably ionomers sold by E. I. DuPont De Nemours & Company under the name SURLYN.

Thread wound balls with ionomer covers are less costly to manufacture than balls with balata covers. They are more durable and produce satisfactory flight distance. However,

these materials are relatively hard compared to balata and thus lack the "click" and "feel" of a balata covered golf ball. "Click" is the sound emitted from the impact of a golf club head on a golf ball. "Feel" is the overall sensation transmitted to the golfer through the golf club after striking a golf ball.

In an attempt to overcome the negative factors of the hard ionomer covers, DuPont introduced low modulus SURLYN ionomers in the early 1980's. These SURLYN ionomers have a flexural modulus from about 3000 to about 7000 PSI and peak hardness from about 25 to about 40 as measured on the Shore D scale - ASTM 2240. The low modulus ionomers are terpolymers, typically of ethylene, methacrylic acid and n- or iso-butylacrylate, neutralized with sodium, zinc, magnesium or lithium cations. E.I. DuPont De Nemours & Company has disclosed that the low modulus ionomers can be blended with other grades of previously commercialized ionomers of high flexural modulus from about 30,000 to 55,000 PSI to produce balata-like properties. However, "soft" blends, typically 52 Shore D and lower (balata-like hardness), are still prone to cut and shear damage.

The low modulus ionomers when used without blends, produce covers with very similar physical properties to those of balata, including poor cut and shear resistance. Worse, wound balls with these covers tend to go "out-of-round" quicker than wound balls with balata covers. Blending with hard SURLYN ionomers was found to improve these properties.

Another approach taken to provide a golf ball cover that has the playing characteristics of balata is described in U.S. Patent No. 5,334,673 ("the '673 patent") assigned to the Acushnet Company. The '673 patent discloses a cover composition comprising a diisocyanate, a polyol and a slow-reacting polyamine curing agent. The diisocyanates claimed in the '673 patent are relatively fast reacting. Due to this fact, catalysts are not needed to lower the activation energy threshold. However, since relatively slow-reacting curative systems are used, a catalyst is added to speed the reaction.

Because a catalyst is used, the reaction rate cannot be easily controlled thereby requiring the implementation of substantial processing controls and precise reactant concentrations in order to obtain a desired product.

5           Isaac (U.S. Patent No. 3,989,568) does not disclose toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, Isophorone diisocyanate or their mixtures. He teaches a step-wise process for making polyurethane-based golf ball covers. The process involves the steps of making sheets, cutting the  
10 sheets into square preforms, molding half-shells, compression molding golf balls along with a post-cure or extended compression molding cycle. The Isaac process requires the addition of a catalyst to the polymer system.

15           The Isaac process cannot be used with the components of the presently disclosed polyurethane system. The compression molding taught by Isaac is damaging to the core of a golf ball that is made with thread windings. According to the Isaac process, the compression molding takes place at 240°F for 5 minutes or, to eliminate the post-cure, for 10-12 minutes.  
20 Under either conditions, the performance characteristics of the thread wound core of the golf ball would be unacceptably compromised. In contrast, a golf ball made in accordance with the components and processing steps of the instant invention would experience a temperature of less than 160°F for only  
25 about 5 minutes.

          Furthermore, the post-cure of Isaac requires preferably two months at room temperature for completion. Two months work-in-process is impractical. The presently disclosed process overcomes this problem by a novel combination of  
30 components and processing steps that requires only an 8 hour room-temperature post-cure which amounts to .56% of the time required by Isaac. Apart from this difference, the present invention's claimed components and process eliminate many of the steps of Isaac such as the post-cure requirement.

35           The Isaac process is further incompatible with the presently claimed chemistry and process since with the presently claimed chemistry and process, a thermoset polymer

is produced from a liquid mixture in less than one minute. The resulting thermoset polymer cannot be re-formed under heat or pressure. Neither Wu nor Presswood (U.S. Patent No. 4,631,298) provide teachings to overcome this problem and, in fact, teach away from being combined with Isaac to obviate the presently claimed invention.

Wu discloses prepolymer compositions based on diisocyanates and polytetramethylene ether glycol with a slow reacting curing agent and method of producing golf ball covers. Presswood discloses the use of fast and slow reacting polyamines to cure polyurethane polymers. The two references teach away from each other as well as Isaac for the following reasons.

The chemistry disclosed by Wu, which involves a prepolymer, a slow reacting diamine and a catalyst caters to a method involving several manufacturing steps. This method includes several curing steps requiring a combined 66-94 minutes and the use of a catalyst, which makes the process very difficult to control. Wu is further limited to a multi-stage molding process as described in columns 5 and 6. The presently disclosed composition could not be used in a process as described by Wu nor could the chemistry of Wu be used in the presently disclosed process. The amount of catalyst that is required to use the chemistry of Wu in The presently disclosed process would make the reaction uncontrollable and thus unsuitable for manufacturing purposes. The relatively rapid cure of The presently disclosed composition would be unsuitable in the multi-stage process of Wu. In short, the chemistry and process of Wu is incompatible with The presently disclosed chemistry and process. As such, Wu teaches away from The presently disclosed claimed composition and chemistry even in view of Isaac and Presswood.

Although Presswood discloses a curing agent blend, it is taught as being used in a reaction injection molding (RIM) process that has novelty due to the high green strength resulting in fast RIM cycle times. A golf ball cover molded by a RIM process is not feasible using current engineering

practices. Locating a spherical wound core in a spherical molded cover cannot be accomplished in one step as suggested by the teachings of Wu, Isaac, Ward (U.S. Patent No. 3,147,324, discussed below) or Watson (U.S. Patent No. 3,130,102, discussed below).

The chemistry and process of The presently disclosed claimed invention is not compatible with a RIM process. First, the speed of a RIM process, even with the use of slow reacting curing agents, is far too fast to accomplish the task of placing a core in the curing polymer. Because of the rapid speed of the reaction, even if the cover were poured in hemispherical segments, by the time the second hemisphere was poured, there would not be enough reactivity left in the second poured half to bond to the first poured half. The reaction time is simply too quick for current production methods.

Second, it would not be possible to suspend a core within the center of a mold using the RIM process. The uneven surface of a wound core would not allow for adequate centering and would produce an inferior golf ball. Additionally, the use of pins to suspend a core in the approximate center of a mold would cause additional problems when the thermoset composition of The presently disclosed claimed composition would adhere to the pins and thus make it impractical. Again, from a manufacturing perspective, the teachings of Presswood are not compatible with The presently disclosed claimed chemistry or process.

A further problem with the teachings of Presswood is the resulting high green strength of the polymer. The presently disclosed claimed composition and process produce a polymer with low green strength which does not allow for quick removal from the molds being used. The presently disclosed composition is only compatible with a cast process.

Accordingly, Presswood does not teach or motivate one skilled in the art when viewed with the process of Isaac and the chemical component teachings of Wu to provide a catalyst-free polyurethane system that eliminates a number of



processing steps including long post-cure periods to provide a polyurethane-covered golf ball exhibiting superior playability characteristics.

5 The presently disclosed process, as claimed, is designed to be relatively fast and continuous. These characteristics of the presently disclosed process are dictated by the novel chemistry as claimed. The process disclosed in Ward differs markedly from The presently disclosed process in that The presently disclosed process produces a thermoset polymer from  
10 a liquid mixture in less than one minute. The presently disclosed claimed composition cannot be reformed under heat or pressure. The teachings of Ward's process retards the curing process. Ward's process is incompatible and does not render obvious The presently disclosed process since use of Ward's  
15 process with The presently disclosed composition would result in the initial cure of the first mold half containing the golf ball core being complete before the second mold half is filled with urethane mixture. Our invention requires the second mold half to be filled after the first mold half and before the  
20 core is loaded into the first mold half. Ward does not teach this sequence. Neither Isaac nor Watson teach this sequence.

Watson specifically teaches the manufacture of golf balls from half-shells that have been frozen to halt the curing process. These steps are inherently slow and expensive and  
25 thus undesirable. The presently disclosed process eliminates the need to halt the curing process and in fact teaches a way of streamlining and maximizing the speed of the process without compromising the superior characteristics of the final product.

30 Isaac also teaches the interruption of the processing cycle by describing how to partially cure the polyurethane which allows the half-shells to be produced and handled and then compression molded to form dimples and the cover around the core. The presently disclosed claimed process eliminates  
35 the delays caused by the process of Isaac. The presently disclosed composition also does not allow the use of the process teachings of Isaac. Watson and Isaac teach how to

arrest the curing process. The presently disclosed claimed process teaches how to streamline and speed the process.

To avoid the problems associated with fast-reacting prepolymer systems, slow-reacting systems such as Toluene diisocyanate (TDI) prepolymer systems can be employed. However, these systems, while avoiding the problems associated with fast-reacting systems, present similar problems, albeit for different reasons. The most noteworthy problem with slow-reacting pre-polymer systems is the requirement for a catalyst.

By introducing a catalyst into the system, processing problems similar to those associated with fast-reacting prepolymer systems are virtually inevitable. As is well known in the art, the use of a catalyst can severely restrict the ability to control the speed of the reaction, which is undesirable.

It has now been discovered that a blend of diamine curing agents with slow-reacting prepolymer systems eliminates the problems associated with catalysts while maintaining the advantages associated with slow-reacting prepolymer systems. Accordingly, it is an object of the present invention to provide a golf ball cover composition that does not require a catalyst.

It is another object of the present invention to provide a golf ball having a synthetic cover material that achieves the click, feel, playability and flight performance qualities of balata covered golf balls.

It is yet another object of the invention to provide a polyurethane formula that achieves hardness characteristics similar to those associated with balata without compromising the durability of the polyurethane material. In contrast, polyurethane systems such as those disclosed in the '673 patent produce relatively high hardness ranges that obviate the possibility of providing a polyurethane system that can truly mimic the feel and playability of a balata-based product.

It is yet another object of the invention to put a

urethane cover on a golf ball core in a single manufacturing step.

It is yet another object of the invention to provide a polyurethane formula that eliminates the damaging high temperature post cure operation.

A further object of the present invention is to provide a golf ball cover material that has improved manufacturing process as well as improved durability and resilience over balata.

#### SUMMARY OF THE INVENTION

Polyurethane compositions comprising the reaction of a polyurethane prepolymer and a curing agent are disclosed. The prepolymer comprises a diisocyanate such as Toluene diisocyanate (TDI) and a polyol such as polytetramethylene ether glycol (PTMEG). The curing agent is a blend of a slow-reacting diamine with a fast-reacting diamine such as dimethylthio 2,4- toluediamine and diethyl 2,4- toluediamine, respectively.

In a preferred embodiment, TDI prepolymer having a low free isocyanate content (low free TDI, as sold in the trade by Uniroyal Chemical Company and Air Products under the trade names Low Free and Perfect Prepolymer, respectively) is used to reduce adverse effects that can arise from exposure to unreacted isocyanate. The curing agent blend provides flexibility to the formulation by eliminating the need for a catalyst. Nevertheless, the present invention can be produced using non low free prepolymers.

The present invention provides a composition suitable for molding a durable golf ball cover with the desirable characteristics of a balata golf ball cover.

These and other objects and features of the present invention will be apparent from a reading of the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a Differential Scanning Calorimeter ("DSC") graph of one embodiment of the polyurethane system of the present invention using a "low temperature" golf ball cure, as desired.

FIG. 2 is a DSC graph of the same embodiment as FIG. 1 using an extended "high temperature" golf ball cure.

FIG. 3 is a schematic of a first step of the molding process according to one embodiment of the invention.

FIG. 3a is a top view of a first mold half according to one embodiment of the invention.

FIG. 3b is a side view of a first mold half according to one embodiment of the invention.

FIG. 3c is a top view of a second mold half according to one embodiment of the invention.

FIG. 3d is a side view of a second mold half according to one embodiment of the invention.

FIG. 3e is a side view of a wedge according to one embodiment of the invention.

FIG. 3f is a plan view of the golf ball molding apparatus.

FIG. 3g is a side elevational view of an x-y table, mold half and mix head according to one embodiment of the invention.

FIG. 3h is a top view of an x-y table in relation to a conveyor belt of the golf ball molding apparatus.

FIG. 3i is a front elevational view of a mold holding apparatus, mold half and conveyor belt of the golf ball molding apparatus according to one embodiment of the invention.

FIG. 3j is a side elevational view of a core holding apparatus and core rack in relation to a conveyor belt holding a pair of mold halves according to one embodiment of the invention.

FIG. 3k is a side elevational view of a core holding apparatus holding a core over a mold half according to one embodiment of the invention.

FIG. 3l is a bottom view of a core holding apparatus according to one embodiment of the invention.

FIG. 3m is an end view of a cooling booth according to one embodiment of the invention.

FIG. 3n is an elevational view of a core spraying apparatus according to one embodiment of the invention.

FIG. 4 is a schematic of one step of the molding process according to one embodiment of the invention.

FIG. 5 is a schematic of another step of the molding process according to one embodiment of the invention.

FIG. 6 is a schematic of a further step of the molding process according to one embodiment of the invention.

FIG. 7 is a schematic of a still further step of the molding process according to one embodiment of the invention.

FIG. 8 is a schematic of yet another step of the molding process according to one embodiment of the invention.

FIG. 9 is a schematic of a yet further step of the molding process according to one embodiment of the invention.

FIG. 10 is a still another step of the molding process according to one embodiment of the present invention.

FIG. 11 is a golf ball according to one embodiment of the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

As is well known in the art, polyurethane can result from a reaction between an isocyanate-terminated polyurethane prepolymer and a curing agent. As shown in FIG. 3, the polyurethane prepolymer is produced when a diisocyanate is reacted with a polyol. The prepolymer is then reacted with the curing agent. The curing agent can be either a polyamine or a polyol. Production of the prepolymer before addition to the curing agent is known as the prepolymer process. In what is known as a one-shot process, the three reactants, diisocyanate, polyol and curing agent are combined in one step. Of the two processes, the prepolymer process is preferred since it allows for greater control over the

reaction. Nevertheless, the present invention can be produced using either process.

5 In one embodiment as shown in FIGS. 3-10, the prepolymer comprised of diisocyanate and polyol is heated to approximately 140°F while the curing agent is maintained at approximately 72°F. The two materials are then mixed in the mixer, along with a colorant, and poured into a first set of golf ball mold halves and allowed to react for approximately 20 to 120 seconds. Within this time, a golf ball core is 10 suspended in the mold halves until the polyurethane has partially cured. A second set of mold halves is also filled with the same polyurethane mixture. The first set of mold halves are then inverted and placed over the second mold halves so that a complete ball is produced. The specifics of 15 the process are explained in greater detail below.

Of notable importance to the present invention is the variety of curing agents that have been previously used to produce urethane elastomers. For example, the curing agents disclosed in the '673 patent are slow-reacting polyamines or 20 polyols. As described in the '673 patent, slow-reacting polyamines are diamines that have amine groups which are sterically and/or electronically hindered by electron withdrawing groups or bulky groups situated proximate to the amine reaction sites. The spacing of the amine reaction sites 25 will also affect the reactivity speed of the polyamines.

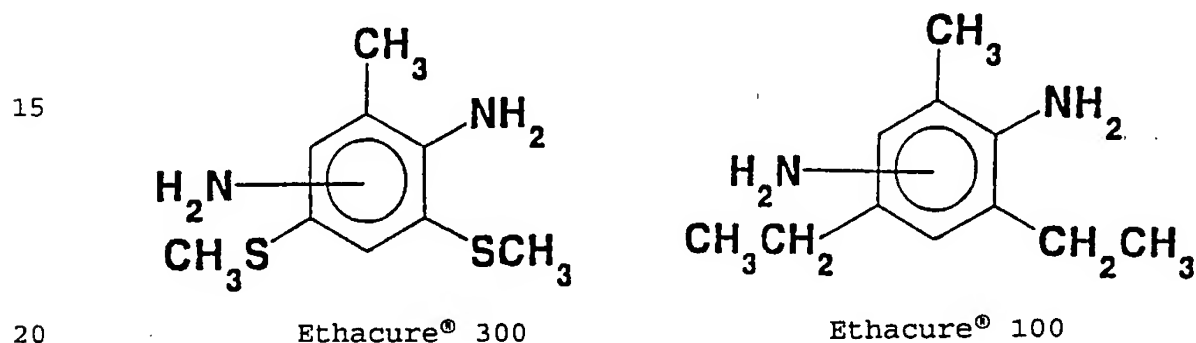
When slow-reacting polyamines are used as the curing agent to produce urethane elastomers, a catalyst is typically needed to promote the reaction between the urethane prepolymer and the curing agent. Unfortunately, as is well known in the 30 art, the use of a catalyst can have a significant effect on the ability to control the reaction and thus, on the overall processibility.

To eliminate the need for a catalyst, a fast-reacting curing agent can be used. Such fast-reacting curing agents, 35 e.g., diethyl-2,4-toluene diamine, do not have electron withdrawing groups or bulky groups that interfere with the reaction groups. However, the problem with lack of control

associated with the use of catalysts is not completely eliminated since fast-reacting curing agents are also relatively difficult to control.

It has now been discovered that a blend of a slow-reacting curing agent and a fast-reacting curing agent eliminates the problems associated with using either type of curing agent in isolation. The ultimate result of such a combination is the realization of greater control and concomitant flexibility over the reactions used to produce urethane elastomers.

In accordance with the present invention, the curing agents used are substantially as shown below:



In cases where resistance of the golf ball cover to discoloration due to ultraviolet light exposure is of importance, Ethacure® 100 LC is used.

One advantage that warrants immediate mention is the elimination of a post cure period. One of the major drawbacks with prior systems is the requirement for a post cure period during which other components of a golf ball can be detrimentally affected by the curing process. For example, it is not unusual for golf balls made with known polyurethane systems to require a post cure at temperatures exceeding 140°F for over eight hours. Three-piece golf balls with rubber windings exhibit reduced compression when exposed to such "high temperature" post cure conditions. Specifically, when rubber windings are used in three-piece golf balls, long exposure to high heat leads to relaxation of the windings or thread and hence reduction in compression values and initial

velocity. With the curing agent blend of the present invention, the problems associated with a post cure period are effectively eliminated.

5       With respect to the diisocyanate component, it is well known in the golf ball industry that toluene diisocyanate (TDI) provides additional processing flexibility to the system unlike any other diisocyanate tested. For example, when 4,4'-diphenylmethane diisocyanate (MDI) is used, the ratio  
10       tolerances (prepolymer-to-curing-agent ratio) are much tighter compared to when TDI is used. Unless strict ratios are adhered to, urethane polymers made with MDI will not have the desired end properties, such as hardness and compression.

15       A still further problem with MDI is that it reacts much faster when reacted with an amine curing agent than does TDI. Thus, some of the control achieved by using the aforementioned curing agent blend is lost when MDI is used.

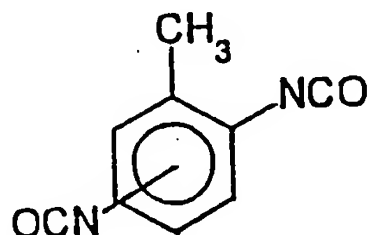
20       An additional disadvantage with an MDI-based system is the need for an elevated curing temperature even though a post-cure period is eliminated by the curing agent blend. Although MDI-based systems can be cured at room temperature by using curing agents such as Polamine® (Polaroid Corporation),  
25       the system is cost prohibitive. Polamine® costs as much as four times the equivalent amount of the curing agents used in the present invention. This renders the use of Polamine® much less cost effective. Furthermore, current technology does not allow prepolymer manufacturers to produce low free MDI prepolymers.

30       In contrast, a TDI-based system is essentially a low-cost "room temperature cure system" in that once the TDI-based polyurethane prepolymer is reacted with the curing agent blend, the composition can be cured at room temperature. This prevents any adverse effects an elevated curing temperature could have on the threading and/or core of the golf ball being produced.

35       Accordingly, in order to maximize the reaction control obtained by using the curing agent blend, TDI has proven to be the best choice for the diisocyanate component. A TDI-based



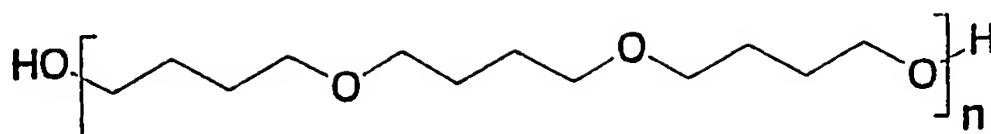
polyurethane system not only complements but enhances the slow reacting system achieved using the curing agent blend. The diisocyanate used in accordance with the present invention is substantially the diisocyanate shown below:



TDI

A similar situation was discovered when selecting the polyol component. For the slow curing system of the present invention, the preferred polyol is polytetramethylene ether glycol (PTMEG). Like urethane elastomers made with other ether polyols, urethane elastomers made with PTMEG exhibit good hydrolytic stability and good tensile strength. Hydrolytic stability allows for a golf ball product that is substantially impervious to the effects of moisture. Thus, a golf ball made with a polyurethane system that has an ether glycol for the polyol component will have a longer shelf life, i.e., retain physical properties under prolonged humid conditions.

Unlike urethane elastomers made with other ether polyols, e.g., polypropylene ether glycol, urethane elastomers made with PTMEG exhibit superior dynamic properties such as coefficient of restitution (COR) and Bashore rebound resilience. The polyurethane-polyurea chemical links that are formed when PTMEG is used with a diamine curing agent provide good thermal stability under elevated temperatures. As a result, hardness stability can be achieved over temperatures consistent with playing and storage conditions. The polyol used in accordance with the present invention is substantially as shown below:



PTMEG (n= 4 to 6)

The polyurethane compositions of the invention are prepared by reacting a prepolymer of a diisocyanate and a polyol. The prepolymer must have an NCO% content of between 5.0% and 8.0% by weight of the prepolymer. Preferably the NCO% content is about 6% by weight.

In one embodiment, 100 grams of a prepolymer (6% NCO) comprising low free TDI and PTMEG is combined with 13.2 grams of a curative being a 50/50 blend by weight of Ethacure® 300 and Ethacure® 100 (utilizing a stoichiometry of 95%). The prepolymer is heated to 140°F in a vat 1 as shown in FIG. 3. The prepolymer and curative components are combined and mixed together in a mixer 3 as shown in FIG. 3. The mixture 5 is poured via mix head 41 into a cavity 40 of a first mold half 4 that is preheated to approximately between 110°F and 160°F in an oven 72 as shown in FIGS. 3f, 3g and 4. The gel time or pot life for this mixture is approximately 20 - 70 seconds.

In a preferred embodiment, mold half 4 is releasably joined with second mold half 7 via mated keyhole slots and pins. As shown in FIGS. 3a and 3b, pins 30 extend laterally from a side of mold half 4 and engage keyhole slots 33 provided in second mold half 7 (FIGS. 3c and 3d). Transportation of mold halves 4 and 7 is accomplished by a conveyor 47 as shown generally in FIG. 3f. To begin the process, mold halves 4 and 7 are preheated in oven 72. After heating, the mated mold halves are transported to a cover material loading station A. A mold removal cylinder 45a

pushes the joined mold halves off conveyor 47 and onto a table 42 known as an X-Y table. The two mold halves are filled with mixture 5 sequentially via positioning under mix head 41 extending from mixer 3. Positioning of the mold halves under the stationary mix head 41 is accomplished by moving table 42 upon which the mold halves have been placed. The computer-guided X-Y table 42 is selectively moved under mix head 41 after the mold halves have been mechanically placed on a preselected initial spot on the X-Y table which is bounded by guide rails 45a and 45b as shown in FIGS. 3g and 3h. After the mold halves have been placed, table 42 is moved along two axes on two pairs of perpendicular rails, first x-y table rails 43 and second x-y table rails 44, in order to center each mold cavity 40 under mix head 41. Once the mold cavities 40 are filled, the mated mold halves are mechanically pushed onto a conveyor belt 47 by mold return cylinder 45b so that the mold halves can be transported to a core loading station B.

Referring to FIGS. 3f, 3j and 3k, initial alignment of the mold cavities with a core loading apparatus 48 along three axes is accomplished by the combination of conveyor belt 47, guide rails 49 situated above each lateral edge of conveyor belt 47 and a core loading station end stop 50 extending inwardly over conveyor belt 47 from one lateral edge of a conveyor belt support frame 51. The height of guide rails 49 and end stop 50 above conveyor belt 47 is set to physically engage the mated mold halves.

Guide rails 49 provide initial lateral alignment (x axis alignment), of the mold halves relative to the core loading apparatus 48. It is important to the function of the system that guide rails 49 be situated such that the mated mold halves do not bind between guide rails 49.

End stop 50 arrests movement of the mated mold halves on the constantly moving conveyor belt 47 until the conveyor stops and provides initial positioning of the mold halves with the core loading apparatus 48 along a y axis which runs along the length of conveyor belt 47. Conveyor belt 47 provides initial positioning of the mold halves with core loading apparatus 48 along a z or vertical axis.

Following initial positioning of the mated mold halves with core loading apparatus 48, after approximately 35 seconds, a golf ball center or wound core 6 is lowered into a cavity 40 of mold half 4 which contains "semi-gelled" polyurethane 5 as shown in FIG. 5. As used herein "semi-gelled" shall mean about an approximate doubling of the viscosity of the mixture.

With respect to three-piece balls having wound cores, prior to placement in cavity 40, wound core 6 is sprayed with a polyurethane-acrylic based coating to protect the windings from the high temperatures of mixture 5 as shown in FIG. 3n. Without the polyurethane coating, the windings would denature and lose tension when subjected to the relatively high temperatures of mixture 5.

As shown in FIG. 3n, the core spraying station is comprised of a conveyor 80 upon which core holding assemblies 81 are attached. Core holding assemblies 81 have three pin-like fingers set approximately 120° apart to support cores 6. A polyurethane spray head 82 envelopes cores 6 with a polyurethane-acrylic based coating 83 that dries at ambient temperatures.

Turning back to the golf ball molding apparatus and referring again to FIGS. 3j and 3k, placement of core 6 into polyurethane gel-filled cavity 40 is accomplished with a vacuum pickup 52 that uses vacuum pressure to "grasp" and "hold" core 6. Vacuum pickup 52 is attached to core holding

apparatus 48 which is suspended by two parallel pairs of perpendicularly oriented guide rails, first core holding apparatus rails 52b and second core holding apparatus rails 52c, which allow for the movement of core holding apparatus 48 along two axes. Once a core 6 has been secured to vacuum pickup 52 from a core holding channel 52a, core holding apparatus 48 is moved, via computer guidance, into position over cavity 40 so that vacuum pickup 52 is situated over the exact hemispherical center of cavity 40. As shown in FIG. 31, vacuum pickup 52 has apertures 53 which contain bushings 54 which are sized to matingly engage vertical pins 37 which project upwardly from mold half 4. The mating of vertical pins 37 and apertures 53/bushings 54 provide a second final alignment. Vacuum pickup 52 is then lowered so that the center or core 6 (depending on whether the golf ball being manufactured is a two-piece or three-piece ball, respectively), is partially engulfed by the "semi-gelled" polyurethane 5 and positioned to be in the exact center of the finished golf ball.

As stated, final alignment occurs when pins 37 are mated with apertures 53/bushings 54. It is important to note that the combination of the pins and apertures do not alone hold mold half 4 in place. At all times, pins 37 are free within apertures 53. Any movement restriction of mold half 4 is accomplished by the combination of apertures 53 of the core holding apparatus 48, pins 37 and conveyor belt 47 which exerts a force on, and supports, mold half 4.

As described above, shortly after the first mold half 4 is filled with the polyurethane mixture 5 (about between 12-20 seconds later), a second mold half 7 is filled with the same polyurethane mixture 5 as shown in FIG. 7. After approximately 10 - 20 seconds of core hold time in mold half

4, first mold half 4 is mated with second mold half 7 containing the same polyurethane prepolymer-diamine curing agent mixture by inverting the first mold half 4 as shown in FIGS. 8 and 9.

5 Referring now to FIG. 3i, a mold holding apparatus 55 configured in the shape of a two tine fork as shown in FIG. 3i, has tines 56 which are spaced to accommodate the length dimension of the mold halves. Mold holding apparatus 55 is independent from core holding apparatus 48 and is suspended from a frame that is attached to two parallel pairs of rails, first mold holding apparatus rails 57 and second mold holding apparatus rails 58, which are oriented perpendicularly to allow movement of the mold holder in two axes. Tines 56 of mold holding apparatus 55 have rotatable mold grippers 59 situated at distal ends of tines such that mold grippers 59 face inwardly. Mold grippers 59 are designed to releasably attach to the mold halves.

20 Shortly after core holding apparatus 48 releases core 6, preferably within a fraction of a second later, mold holding apparatus 55 is lowered to allow engagement of mold grippers 59 with mold half 4. After engagement, mold holding apparatus 55 is raised thereby detaching first mold half 4 from second mold half 7. At this time, second mold half 7 is still stationary as its movement is arrested by end stop 50.

25 After mold half 4 has been lifted a predetermined height, mold grippers 59 are rotated approximately 180° so that core 6 is suspended above conveyor belt 47. Mold holding apparatus 55 is then moved along perpendicular rails 57 and 58 until mold half 4 is aligned over second mold half 7. Mold holding apparatus 55 is then lowered until pins 37 of first mold half 4 are matingly engaged by apertures 60 in second mold half 7. The initial alignment of mold half 4 to second mold half 7 by

mold holding apparatus 55 is followed by final alignment of the mold halves when pins 37 are mated with apertures 60. Thus, pins 37 have dual functions: 1) final alignment of core 6 with cavity 40 and, 2) final alignment of the mold halves.

5 Referring to FIGS. 3c and 3d, to secure the mold halves together, lateral apertures 34 which open on opposite ends of second mold half 7 are situated to be perpendicular to, and intersect, apertures 60. Fitted loosely within lateral apertures 34 are wedges 35 (FIGS. 3d and 3e), that are sized  
10 to slidably engage the walls of lateral apertures 34. Lateral apertures 34 open on the edges of second mold half 7 that face the lateral edges of conveyor 47 to allow for manipulation of wedges 35.

As shown in FIG. 3b, pins 37 have slots 38 provided..  
15 therein which align with lateral apertures 34 when pins 37 are matingly engaged to apertures 60. After first mold half 4 is placed into contact with second mold half 7, a pancake cylinder 61 applies pressure onto a bottom surface of mold half 4 to secure mold half 4 to second mold half 7 (FIG. 3i).  
20 Simultaneously with the action of pancake cylinder 61, wedge drivers 62 situated above a lateral edge of conveyor 47, intermittently strike wedges 35 into slots 38 until the mold halves are securely locked together.

After approximately four minutes of heating and three  
25 minutes of cooling, the golf ball is removed from the mold and allowed to post cure at room temperature for 8-16 hours, FIGS. 9 and 10. Referring to FIG. 3f, to heat the formed golf balls, the joined mold halves are transported on conveyor 47 to a heating station C where the golf balls are heated for  
30 approximately four minutes in a heating oven 63. Next, the joined mold halves are rotated onto an edge via rotation ramp 64 which causes rotation of the joined mold halves when

conveyor 47 transports the mold halves into ramp 64. The mold halves which are now oriented with the bottoms of the mold halves facing the lateral edges of conveyor 47 are transported to a cooling station D where the joined mold halves are transported through a cooling hood 65 which contains spray nozzles 66 which forcibly deliver cool water 67 to the bottoms of mold halves 4 and 7 as shown in FIG 3m.

Referring again to FIG. 3f, to disengage the joined mold halves, the mold halves are transported to a mold disengagement station E. A counter-rotation ramp 68a rotates the joined mold halves onto the bottom of first mold half 4. To arrest movement of the joined mold halves at station E, one of the lateral pins 37 collides with disengagement stop 68. Slots 39 provided in opposing ends of mold half 4 are engaged by a mold holding fork 70 with tines sized to engage slots 39. After mold half 4 has been secured by mold holding fork 70, mold releasing pins 71 are forcibly inserted into lateral apertures 34 of second mold half 7 so that wedges 35 are moved out of engagement with pins 37. After disengagement of wedges 35, releasing pins 71, while still in lateral apertures 34, are rotated about an axis parallel to pins 71 to remove second mold half 7 from mold half 4. Second mold half 7 is rotated 180° onto its bottom surface.

To prepare the mold halves for further use, a mold releasing agent that is coated on cavities 40 prior to use of the mold halves can optionally be reapplied, if needed, before transporting the mold halves back to heating oven 72 for further cycling through the golf ball molding process described above.

Removal of the finished golf ball from the mold is facilitated by the mold release agent. The mold release agent can be any substance, e.g., mineral oil, that can attenuate adhesion of the polyurethane cover composition to the mold



cavity. It is to be understood that the releasing agent forms no part of the invention and is described simply for purposes of thoroughness and clarity.

5 If desired, other ingredients, such as pigments, can be added to the mixture. For example, a pigment 2a addition of .25 - 5% by weight of the total polyurethane prepolymer/curative mixture can be added via a third stream to the mixhead at the time of adding the prepolymer and the diamine curing agent to produce the desired color. In a  
10 preferred embodiment, the pigment shall consist of 65%  $\text{TiO}_2$  and 35% carrier (typically a polyol, with or without toners) by weight. The pigment may or may not include other additives including a UV stabilizing package, optical brighteners, etc. In another embodiment, the pigment may be added to the  
15 curative blend prior to the mixhead.

To produce a golf ball in accordance with the invention, in a preferred embodiment, 100 PPHR of prepolymer (low free TDI @ 6% NCO and PTMEG) is heated to 140°F in vat 1 as shown in FIG. 3. 13.2 PPHR of a curative comprising Ethacure® 100  
20 and Ethacure® 300 at a 50:50 weight ratio is maintained at room temperature in second vat 2. The contents of vat 1 and vat 2 are mixed in mixer 3 along with 2.3 PPHR pigment 2a from a third vat as shown in FIG. 3. The mixture 5 is poured into a hemispherical cavity of first open mold half 4 which has a  
25 diameter of about 1.68". After approximately 35 seconds, a golf ball core 6 is lowered into the mold half 4 containing "semi-gelled" polyurethane 5 as shown in FIG. 5.

As shown in FIG. 11, the golf ball is comprised of a polyurethane cover 5a and a core 6. The core 6 has a diameter  
30 of about between 1.52" to 1.62" and preferably about 1.58" and is comprised of a solid core to make a two piece ball or a wound core with a center 6a and a thread windings layer 6b to make a wound three piece ball. The two piece ball is comprised of a solid core made of high cis polybutadiene  
35 rubber. As used herein "high cis" shall mean polybutadiene

rubber with a cis content of about 90% or higher. Also, the core 6 having the same diameter, as mentioned above, when comprised of a solid center 6a with a solid outer core layer 6b both comprised of high cis polybutadiene rubber makes a solid three piece ball.

The wound three piece ball is comprised of a solid or liquid center. The solid center has a diameter of about between 1.40" to 1.53" and preferably about 1.42" and is comprised of 100 PPHR high cis polybutadiene rubber, 20 PPHR Zinc Acrylate salt, 24.5 PPHR Barium Sulfate, 6 PPHR Zinc Oxide, 3 PPHR Zinc Stearate and 2.1 PPHR 1,1-Di-(tert-butylperoxy)-3,3,5-trimethyl cyclohexane (40% active). The liquid center is comprised of a spherical bag made of rubber with liquid inside and has an outer diameter of about between 1.00" to 1.38" and preferably about 1.13". The thread windings layer is comprised of sulfur-cured polyisoprene rubber having a thread thickness about between 0.012" to 0.032" and preferably about 0.017" and a width of about between 1/32" to 3/32" and preferably about 5/64" so that the thread layer thickness is about between 0.05" to 0.31". The wound core which is the combination of the center and thread windings has a diameter of about between 1.52" to 1.62" and preferably about 1.58".

The solid three piece ball is comprised of a solid center of diameter of about between 1.18" to 1.38" and preferably of about 1.23" so that the solid outer core layer thickness is about between 0.07" to 0.22". The solid dual core is the combination of the solid center and the solid outer core and has a diameter of about between 1.52" to 1.62" and preferably about 1.58".

Shortly after the first open mold half 4 is filled with the polyurethane mixture 5, a second hemispherical cavity situated in open mold half 7 is filled with the polyurethane mixture 5 as shown in FIG. 7. Second mold half 7 also has a diameter of about 1.68".

After approximately 10-20 seconds, the first mold half 4

is mated with the second mold half 7 containing the same polyurethane mixture 5 as contained in first mold half 4 by inverting the first mold half 4 as shown in FIGS. 8 and 9.

○ The combination of the polyurethane mixture 5 in each of the mold halves forms the golf ball cover 5a. After approximately 4 minutes of heating and three minutes of cooling, the golf ball is removed from the mold, and allowed to post cure at room temperature for 8-16 hours, FIGS. 9 and 10.

To achieve the desired results, the reactants should be reacted to obtain a stoichiometry of between about 85 - 105% and preferably 95%. With respect to the NCO% content, any prepolymer used should have an NCO% between about 5.0 - 8.0% by weight of the prepolymer and preferably about 6% by weight. Systems using TDI, IPDI (Isophorone diisocyanate) or MDI as the diisocyanate and an ether backbone are all possible choices for the polyurethane prepolymer. The polyol selected should have a molecular weight of between about 650 - 3000 and preferably between about 850 - 2000. The larger the molecular weight, the softer, and more flexible the polyurethane becomes. In the preferred embodiment, PTMEG having a molecular weight of about 1000 is used to obtain desired Bashore rebound resilience and flexural modulus performance characteristics.

○ The curative should be a blend of a slow-reacting diamine and a fast-reacting diamine. In a preferred embodiment, slow-reacting dimethylthio-2,4-toluenediamine sold under the trade name Ethacure 300 by the Albermarle Corporation and fast-reacting diethyl-2,4-toluenediamine sold under the trade name Ethacure 100 by Albermarle, are combined at a ratio of between about 40:60 - 80:20 by weight. Polyurethanes having desirable physical properties have been achieved using the following Ethacure 300/Ethacure 100 blend ratios at the following equivalent weights, respectively: 40:60 at 95.76, 50:50 at 97.47, 60:40 at 99.24, 70:30 at 101.00 and 80:20 at 102.97.

As previously discussed, it is essential that a blend be used to eliminate the need for a catalyst. It has been discovered that the combination of Ethacure 100, which does

not have the thio groups, with Ethacure 300 enables the reaction to take place without the need of a catalyst while still achieving good gel times (a pot life of approximately 20-70 seconds). Due to the absence of the thio groups, steric hindrance is not realized. However, Ethacure 100 used alone acts rapidly and therefore does not provide the desired control over the reaction time. In contrast, Ethacure 300, due to steric hindrance, reacts much slower than Ethacure 100 and requires the undesired catalyst.

If a "room cure" formulation is desired, catalysts, such as Dabco 33 LV from Air Products, are not suitable since they provide exponential exothermic reactions. With few exceptions, once a catalyst is introduced into a urethane system, it is difficult, and, from a commercially practical standpoint, impossible to obtain a desired linear exothermic reaction. Without being able to control the temperature pattern of the reaction, it is difficult to obtain the desired physical properties since the physical properties are temperature sensitive. The curing agent blend of the present TDI-based system provides the desired exothermic reaction so that the desired end-product physical properties can be achieved.

It has been found that a blend of these two curatives allows the reaction time to be controlled. By varying the blend, the speed of the reaction can be controlled to obtain the desired characteristics. With a catalyst, the speed of the reaction cannot be as easily controlled, which ultimately leads to undesired physical properties.

A further surprising advantage of the new system using the Ethacure 300/100 blend is the elimination of a post-cure without losing the benefits of a post-cure period. With many prior art systems, compression is lost if a "high temperature" post-cure period is instituted. With the system of the present invention, good compression numbers can be achieved without a "high temperature" post-cure period. Moreover, curing can be performed at room temperature, i.e., 72°F.

A still further surprising advantage of the preferred

curing agent blend is the flexibility in formula concentrations the new system provides. To change the resulting characteristics, one need only change the concentrations of the reactants. For example, hardness readings ranging from 50D - 65D have been achieved by altering the molecular weight of the polyol component (PTMEG in the preferred embodiment), the NCO% content and/or the stoichiometry of the reaction. Even when the reactant concentrations are altered to achieve different hardness levels, good physical properties can be achieved within a range of alterations.

A yet further advantage, as is well known in the golf ball manufacturing industry, is that the ratio of polymer to curing agent is also more forgiving than other known systems. In contrast, for example, the system disclosed in the '673 patent requires the ratio to be more "exact" in order to produce the desired polymer.

The following examples are provided to illustrate and further explain the aspects of the invention. These examples are set forth for purposes of illustration and do not limit the scope of the invention.

#### EXAMPLE 1

A 6% low free TDI-PTMEG polyurethane prepolymer was heated to 140°F and mixed with a 50/50 blend by weight of Ethacure 300 and Ethacure 100. The curing agent blend was maintained at room temperature before mixing. The exothermic reaction reached between 160°-170°F with a gel time of approximately 65 seconds. The mixture was cured at room temperature for 12 hours.

When tested for hardness using a Shore D Durometer made by Shore Instrument and Mfg. Co., Inc., the composition exhibited a Shore D hardness of 51.0 when measured using ASTM method D-2240-91, "Indentation Hardness of Rubber and Plastic by Means of a Durometer." A Bashore Rebound measurement of 51% was obtained in accordance ASTM D2632 with a Shore Resiliometer also made by Shore Instrument and Mfg. Co., Inc.

Tensile data was compiled using ASTM D412. The composition produced an ultimate stress of 6269 psi, a Young's modulus reading of 5166 psi, a stress at 100% reading of 1909 psi and an elongation reading of 400 - 450% using ASTM D412. Elongation is a measurement of a material's elasticity up to its breaking point under a tensile load. This type of tensile data is obtained because it can be correlated to the ultimate performance characteristics of the polyurethane cover such as cut resistance and shear resistance.

The composition exhibited a flexural modulus of 16650 psi which falls within the desired range of 15,000 - 30,000 psi using ASTM method D-790. With respect to the polyurethane system embodiments of the present invention, flexural modulus increases as Shore D hardness increases.

The final physical parameters tested relate to tear data obtained in accordance with ASTM D624, Die C ("Graves Tear"). The composition produced a maximum load reading of 512 lbf./in., (the load at which the material samples began to tear). An energy to break reading of 24.8 lbf./in. and a energy to yield reading of 18.0 lbf./in. were also obtained.

The foregoing test results demonstrate that a polyurethane material having superior processibility can be achieved that exhibits "high" elongation, tensile strength and tear strength. When used as the material for a golf ball cover, these physical properties translate into a golf ball cover material that exhibits superior cut, abrasion and shear resistance versus ionomers and balata when struck by hard objects such as the grooved face of a metallic golf club head.

In addition to the physical parameter testing, the polyurethane mixture (low free TDI prepolymer mixed with a 50/50 blend of Ethacure 300/Ethacure 100) was subjected to two different post cure environments to determine the effects of the post cure on the physical properties of the polyurethane end product. One part of the mixture was cured at 105°F ("oven cure temperature") for approximately 10 hours. The mixture was then allowed to cool down for approximately two weeks before testing for physical properties. The identical

mixture was cured at 220°F ("extended cure") again for approximately 10 hours and allowed to cool down for approximately two weeks before testing for physical properties.

FIG. 1 shows the DSC results for the "oven cure" trial and FIG. 2 shows the results for the "extended cure" trial. As is clear from the test results, the DSC curves were very similar, taking into account the accuracy of the testing apparatus and the testing method.

When the polyurethane products were tested for physical properties, the products exhibited similar physical properties. These results demonstrate that the polyurethane made with the curing agent blend could be cured without the need for a "high temperature" post cure period or "extended cure" period during which golf ball physical properties can be lost due to the exposure of the other golf ball components, e.g. windings and core, to high temperatures for long periods of time. By using the curing agent blend of the invention, with the elimination of a "high temperature" post cure period, physical properties such as initial velocity and compression can be maintained while achieving "full" reaction of the polyurethane reaction components.

#### Examples 2-4

Additional tests were run using the same low free TDI prepolymer with altered blend ratios of Ethacure 300/Ethacure 100. In each test, the prepolymer was heated to 140°F and the curative blend was maintained at room temperature before being mixed. The tests were conducted to determine the blend effects on gel time and exothermic reaction.

When the blend ratio was set at 60:40 (E100 to E300), a gel time of 55-60 seconds was achieved. The exothermic reaction reached 145°F. A 70:30 blend ratio produced a gel time of approximately 50 seconds and an exothermic reaction that reached 156°F. Lastly, an 80:20 blend ratio produced a gel time of approximately 45 seconds and an exothermic reaction that reached 165°F. All of the polyurethane end

products of these tests were determined to have physical characteristics similar to those of the polyurethane produced using the 50:50 curing agent blend ratio.

These test results conclusively demonstrate the processability advantages of the curing agent blend and the wide range of blend ratios that can be used to produce desired polyurethane end products. Depending on the amount of time needed to pour a particular number of golf ball molds with a single batch of the polyurethane prepolymer mix, a curing agent blend can be picked that will accommodate the speed requirements of the golf ball manufacturing process without having any appreciable effect on the physical characteristics of the end product.

As demonstrated by the preceding examples, there is a great deal of flexibility that can be built into the urethane elastomer system. The curing agent blend ratio can be modified to alter the speed of the reaction to accommodate the practitioner's needs while the diisocyanate NCO% content can be varied to achieve varying physical properties. No other golf ball specific urethane elastomer system is known by the inventors that provides such flexibility.

It will be appreciated that the instant specification and claims are set forth by way of illustration and not made without departing from the spirit and scope of the present invention.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent is:



1. A composition suitable for manufacturing and molding a golf ball cover comprising:
  - (a) a polyurethane prepolymer comprising:
    - (1) a composition wherein the diisocyanate is selected from the group consisting of toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, Isophorone diisocyanate and any mixtures thereof; and,
    - (2) a polyol; and,
  - (b) a curing agent comprising:
    - (1) a slow-reacting diamine; and,
    - (2) a fast-reacting diamine.
2. The composition of claim 1 wherein the polyol is an ether glycol.
3. The composition of claim 1 wherein the polyol is polytetramethylene glycol.
4. The composition of claim 1 wherein the curing agent comprises a slow-reacting diamine with diethyl-2,4-toluenediamine.
5. The composition of claim 1 wherein the curing agent comprises dimethylthio-2,4-toluenediamine and a fast-reacting diamine.
6. The composition of claim 1 wherein the curing agent comprises a blend of dimethylthio-2,4-toluenediamine and diethyl-2,4-toluenediamine.
7. A composition suitable for manufacturing and molding a golf ball cover comprising:
  - (a) a polyurethane prepolymer comprising:
    - (1) a composition wherein the diisocyanate is selected from the group consisting of toluene diisocyanate, 4,4'-diphenylmethane diisocyanate,

Isophorone diisocyanate and any mixtures thereof; and,

(2) a polyol; and,

(b) a curing agent comprising:

(1) dimethylthio-2,4-toluenediamine; and,

(2) diethyl-2,4-toluenediamine.

8. The composition of claim 7 wherein the polyol is an ether glycol.
9. The composition of claim 7 wherein the polyol is tetramethylene ether glycol.
10. A method of making a golf ball comprising:
  - providing a prepolymer comprised of a diisocyanate and a polyol and heating the prepolymer;
  - providing a curative comprised of a slow-reacting diamine and a fast-reacting diamine;
  - mixing the prepolymer with the curative in a mixer to create a polymer mixture;
  - pouring the polymer mixture into the first mold half;
  - pouring the mixture into the second mold half; allowing the mixture to reach a semi-gelled state;
  - lowering golf ball core into the first mold half such that the golf ball core is suspended in the semi-gelled polymer mixture;
  - inverting the first mold half and mating it to the second mold half;
  - heating the mated first and second mold halves containing the polymer mixture and golf ball core;
  - cooling the mated first and second mold halves containing the polymer mixture and golf ball core; and,
  - removing the molded golf ball from the first and second mold halves and allowing the golf ball to cure.
11. The method according to claim 10 wherein the prepolymer is heated to about 140°F.

12. The method according to claim 11 wherein the first and second mold halves are heated to about 160°F.
13. The method according to claim 12 wherein the polymer mixture is allowed to cure for approximately 35 seconds after being poured into the first mold half.
14. The method according to claim 13 wherein the polymer mixture is allowed to cure for approximately 20 to 30 seconds after being poured into the second mold half and before inverting and mating the first mold half with the second mold half.
15. The method according to claim 14 wherein the mated first and second mold halves are heated for approximately 4 minutes and cooled for approximately 3 minutes.
16. The method according to claim 15 wherein the molded golf ball is allowed to cure at room temperature for about between 8 to 16 hours.
17. The method according to claim 10 including the step of adding a pigment to the polymer mixture.
18. The method according to claim 17 wherein the pigment comprises .25 to 5% by weight of the total polymer mixture.
19. A golf ball comprising:
  - a core having a diameter of about 1.52" to 1.62"; and,
  - a cover comprising:
    - (a) a polyurethane prepolymer comprising:
      - (1) a composition wherein the diisocyanate is selected from the group consisting of toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, Isophorone diisocyanate and any mixtures thereof; and,
      - (2) a polyol; and,
    - (b) a curing agent comprising:

- (1) a slow-reacting diamine; and,
  - (2) a fast-reacting diamine.
20. The golf ball of composition of claim 19 wherein the polyol is an ether glycol.
  21. The golf ball of claim 19 wherein the polyol is polytetramethylene glycol.
  22. The golf ball of claim 19 wherein the curing agent comprises a slow-reacting diamine with diethyl-2,4-toluenediamine.
  23. The golf ball of claim 19 wherein the curing agent comprises dimethylthio-2,4-toluenediamine and a fast-reacting diamine.
  24. The golf ball of claim 19 wherein the curing agent comprises a blend of dimethylthio-2,4-toluenediamine and diethyl-2,4-toluenediamine.
  25. The golf ball of claim 19 wherein the core comprises a center and thread windings.
  26. The golf ball of claim 25 wherein the center is a solid or liquid center.
  27. The golf ball of claim 26 wherein the solid center is made of high cis polybutadiene rubber.
  28. The golf ball of claim 26 wherein the solid center has a diameter of about 1.40" to 1.53".
  29. The golf ball of claim 26 wherein the liquid center has a diameter of about 1.00" to 1.38"
  30. The golf ball of claim 25 wherein the thread windings are

made from polyisoprene rubber cured with sulfur.

31. The golf ball of claim 19 wherein the core is a solid core made from high cis polybutadiene rubber.
32. A golf ball comprising:  
a core having a diameter of about 1.52" to 1.62",  
comprising a center and thread layer; and,  
a cover comprising:  
(a) a polyurethane prepolymer comprising:  
(1) a composition wherein the diisocyanate is selected from the group consisting of toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, Isophorone diisocyanate and any mixtures thereof; and,  
(2) a polyol; and,  
(b) a curing agent comprising:  
(1) dimethylthio-2,4-toluenediamine; and,  
(2) diethyl-2,4-toluenediamine.
33. The golf ball of claim 32 wherein the polyol is an ether glycol.
34. The golf ball of claim 32 wherein the polyol is tetramethylene ether glycol.
35. The golf ball of claim 32 wherein the center is a solid or liquid center.
36. The golf ball of claim 35 wherein the solid center is made of high cis polybutadiene rubber.
37. The golf ball of claim 35 wherein the solid center has a diameter of about 1.40" to 1.53".
38. The golf ball of claim 35 wherein the liquid center has a diameter of about 1.00" to 1.38"

39. The golf ball of claim 32 wherein the thread windings are made from polyisoprene rubber cured with sulfur.

40. A golf ball comprising:

a solid center having a diameter of about 1.42" and comprising 100 PPHR high cis Polybutadiene rubber, 20 PPHR Zinc Acrylate salt, 24.5 PPHR Barium Sulfate, 6 PPHR Zinc Oxide, 3 PPHR Zinc Stearate and 2.1 PPHR 1,1-Di-(tert-butylperoxy)-3,3,5-trimethyl cyclohexane (40% active);

a thread winding layer comprised of polyisoprene rubber and having a thread size of 0.017" x 5/64" so that the thread layer thickness is about 0.08" and the combination of the core and thread windings has a diameter of about 1.58"; and,

a cover comprising 100 PPHR of prepolymer (TDI @ 6% NCO and PTMEG), 13.2 PPHR of a curative comprising Ethacure® 100 and Ethacure® 300 at a 50:50 ratio and, 2.3 PPHR pigment so that the overall ball diameter is about 1.68".

41. A golf ball comprising:

a core having a diameter of about 1.52" to 1.62", comprising a solid center and solid outer core layer; and,

a cover comprising:

(a) a polyurethane prepolymer comprising:

(1) a composition wherein the diisocyanate is selected from the group consisting of toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, Isophorone diisocyanate and any mixtures thereof; and,

(2) a polyol; and,

(b) a curing agent comprising:

(1) dimethylthio-2,4-toluenediamine; and,

(2) diethyl-2,4-toluenediamine.

42. The golf ball of claim 41 wherein the polyol is an ether glycol.

43. The golf ball of claim 41 wherein the polyol is

tetramethylene ether glycol.

44. The golf ball of claim 41 wherein the solid center has a diameter of 1.18" to 1.38".
45. The golf ball of claim 41 wherein the solid center and solid outer core are made from high cis polybutadiene rubber.
46. A method of preparing a golf ball having urethane cover comprising the steps of:
- providing two matingly engageable mold halves, a first and second mold half, with at least one cavity situated within a face of each mold half;
  - filling said at least one mold cavity in each mold half with a polyurethane prepolymer comprising a diisocyanate, a polyol and a curing agent comprising a slow-reacting diamine and a fast reacting diamine via a mixhead;
  - transporting said two mold halves with a conveyor belt;
  - arresting movement of said two mold halves on said conveyor belt with at least one guide rail and an end stop;
  - positioning said first mold half below a core loading apparatus;
  - securing a core to said core loading apparatus;
  - positioning said core loading apparatus to align said core over a center of said at least one cavity of said first mold half;
  - lowering said core into said polyurethane prepolymer situated in said at least one cavity of said first mold half so that one half of said core is submerged in said polyurethane prepolymer;
  - releasing said core from said core holding apparatus;
  - positioning a mold holding apparatus over said first mold half;
  - lowering said mold holding apparatus over said first mold half;
  - grasping said first mold half with said mold holding apparatus;

raising said first mold half with said mold holding apparatus;

inverting said first mold half with said mold holding apparatus;

positioning said first mold half over said second mold half so that said at least one cavity in said first mold half is aligned with said at least one cavity in said second mold half;

lowering said first mold half onto said second mold half;  
securing said first mold half to said second mold half such that a second half of said core is submerged in said polyurethane prepolymer situated in said at least one cavity of said second mold half;

curing said polyurethane prepolymer;

releasing said first mold half from said second mold half;

removing a golf ball comprising said core and a cover comprised of polyurethane formed from said polyurethane prepolymer.

47. The method of claim 46 further comprising the steps of:  
providing an X-Y table for positioning said two mold halves under said mixhead;

placing said two mold halves on said X-Y table; and,  
moving said X-Y table along two axes to position said mold halves in alignment and below said mixhead.

48. The method of claim 46 further comprising the steps of:  
situating said least one guide rail above a lateral edge of said conveyor belt to provide initial lateral alignment of said first mold half with said core holding apparatus; and,  
situating said end stop above said conveyor belt to provide initial horizontal alignment of said first mold half with said core holding apparatus wherein the combination of said conveyor belt, said at least one guide rail and said end stop provide initial alignment with said core holding apparatus.



49. The method of claim 46 further comprising the steps of:  
providing said first mold half with at least one pin  
extending above a top face of said first mold half for  
alignment with said core holding apparatus and said second  
mold half.

50. The method of claim 49 further comprising the steps of:  
providing said core holding apparatus with parallel  
pairs of perpendicularly oriented guide rails; and,  
moving said core holding apparatus along said guide rails  
in two axes to position said core holding apparatus over said  
first mold half.

51. The method of claim 50 further comprising the step of:  
providing said core holding apparatus with at least one  
aperture opening on a bottom face of said core holding  
apparatus that is sized to receive said at least one pin of  
said first mold half.

52. The method of claim 51 further comprising the step of:  
lowering said core holding apparatus so that said at  
least one pin of said first mold half is matingly engaged with  
said at least one aperture of said core holding apparatus to  
provide final alignment of said core holding apparatus and  
said first mold half.

53. The method of claim 49 further comprising the steps of:  
providing said mold holding apparatus with two parallel  
pairs of perpendicularly oriented mold holding apparatus guide  
rails and two rotatable mold grippers suspended from said mold  
holding apparatus, whereby said mold grippers are configured  
and oriented to grasp said first mold half;  
grasping said first mold half with said mold gripper;  
and,  
rotating said mold grippers to invert said attached first  
mold half.

54. The method of claim 53 further comprising the steps of:  
moving said mold holding apparatus with said first mold half attached in position over said second mold half by moving said mold holding apparatus along said guide rails; and,  
lowering said first mold half onto said second mold half.

55. The method of claim 54 further comprising the steps of:  
providing said at least one pin of said first mold half with portions that define a wedge slot;

providing said second mold half with at least one aperture opening on a top face of said second mold half and sized to matingly engage said at least one pin of said first mold half;

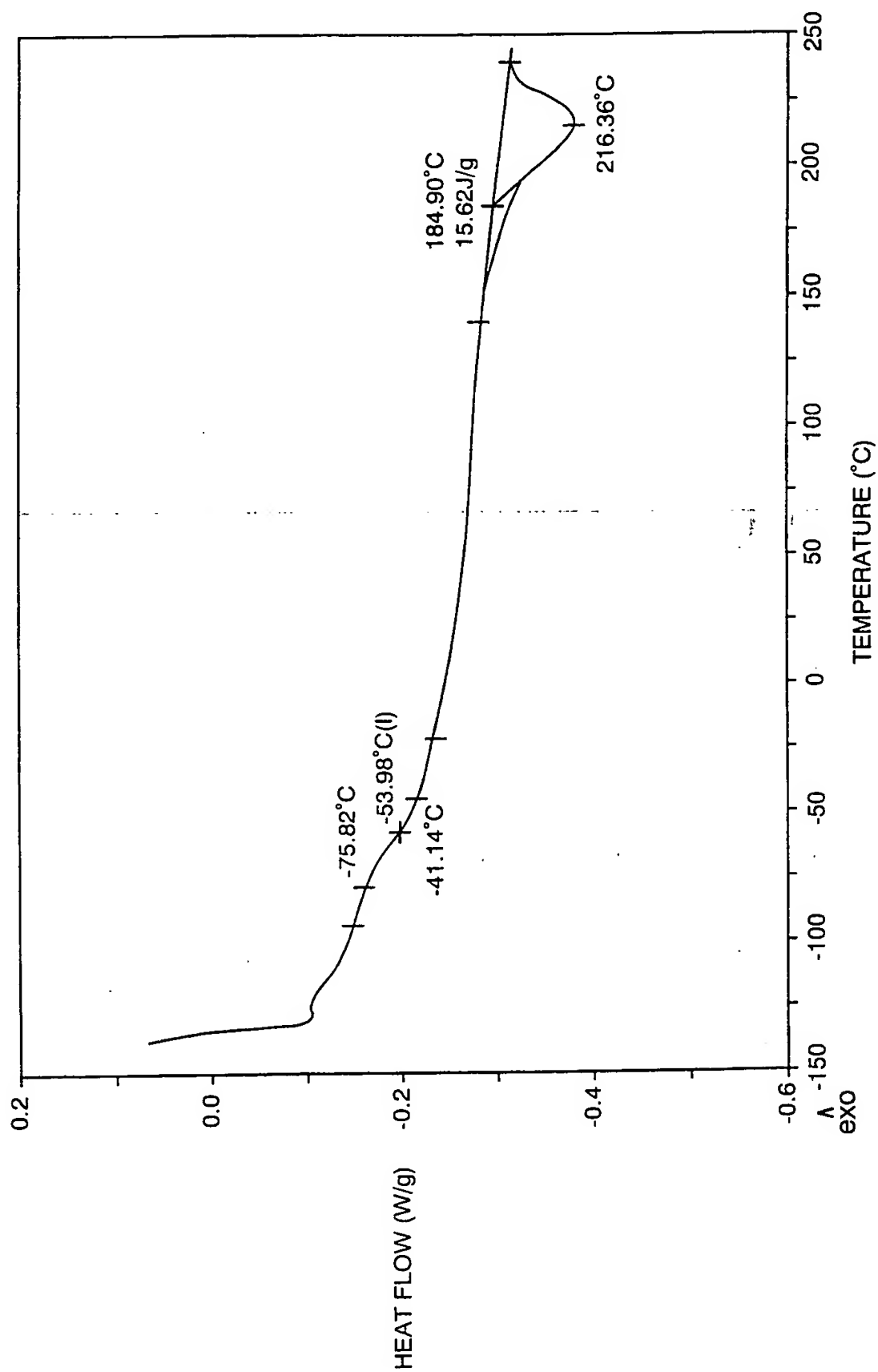
providing said second mold half with at least one wedge aperture which extends from a side of said second mold half to an opposite side of said second mold half;

providing a slidably engageable wedge within said at least one aperture of said second mold half whereby when said first mold half is lowered onto said second mold half so that said at least one pin of said first mold half is mated with said at least one aperture of said second mold half, said wedge is forcibly slid within said wedge aperture until said wedge releasably engages said wedge slot of said first mold half to temporarily lock said mold halves together.

56. The method of claim 55 further comprising the step of providing a bushing sized to fit within said at least one aperture of said second mold half and sized to matingly engage said at least one pin of said first mold half.

57. The method of claim 46 further comprising the step of:  
coating said core with a polyurethane-acrylic coating before inserting and centering said core into said polyurethane mixture in said first mold half in said mold cavity.

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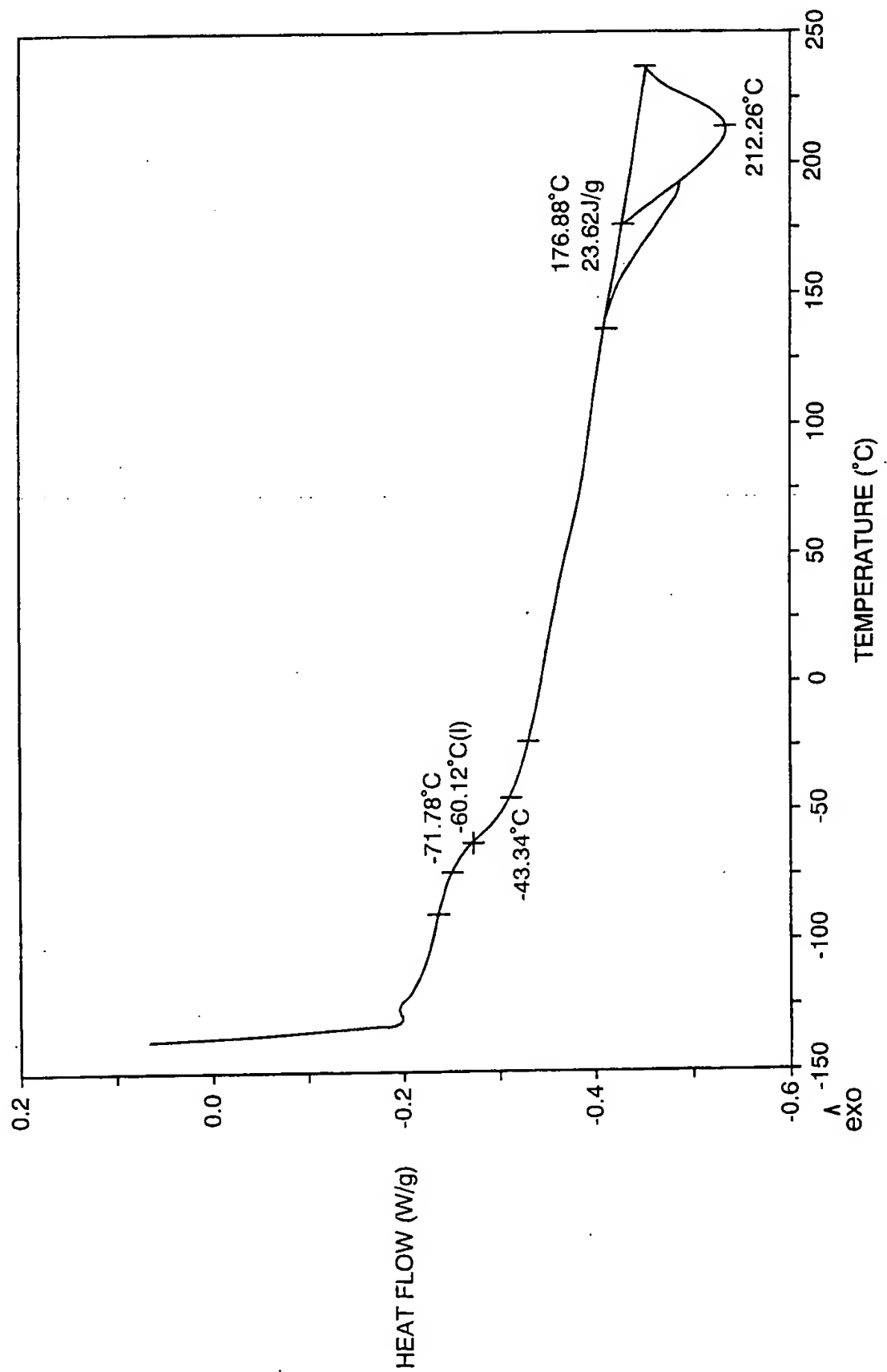


FIG. 2

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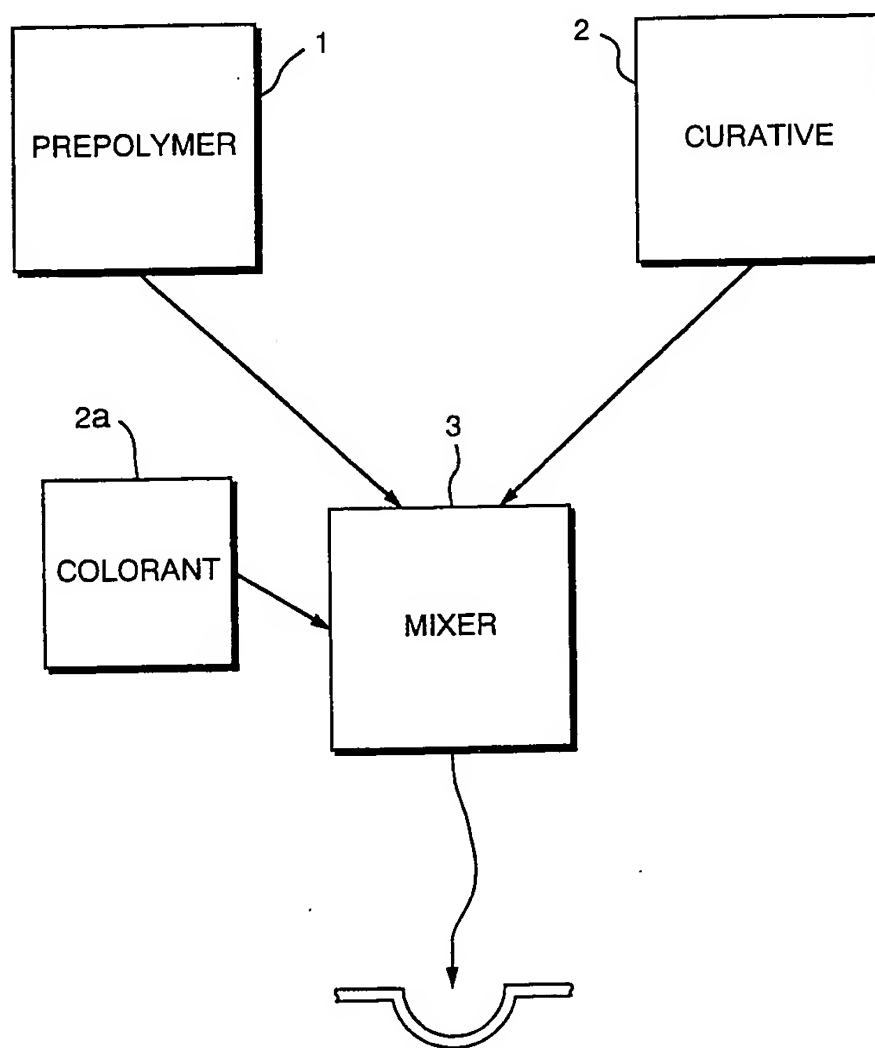


FIG. 3

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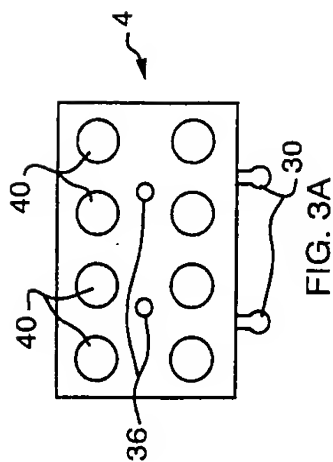


FIG. 3A

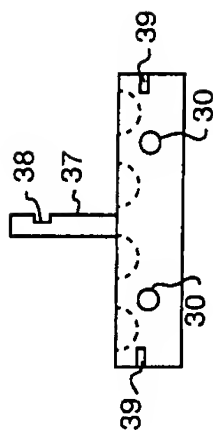


FIG. 3B

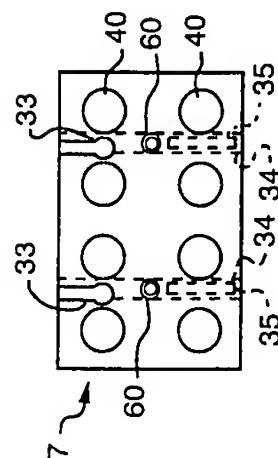


FIG. 3C



FIG. 3D



FIG. 3E

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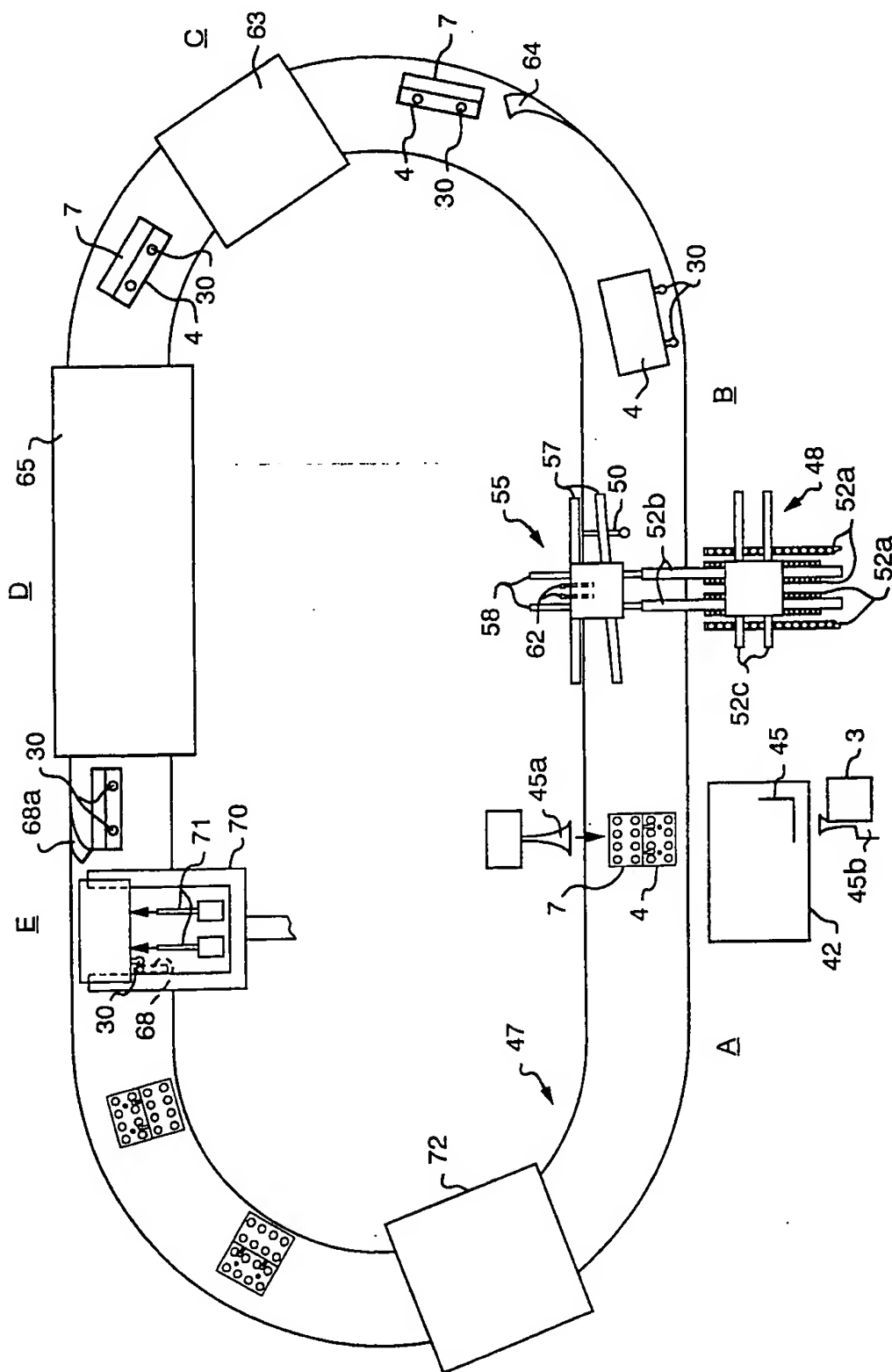


FIG. 3F

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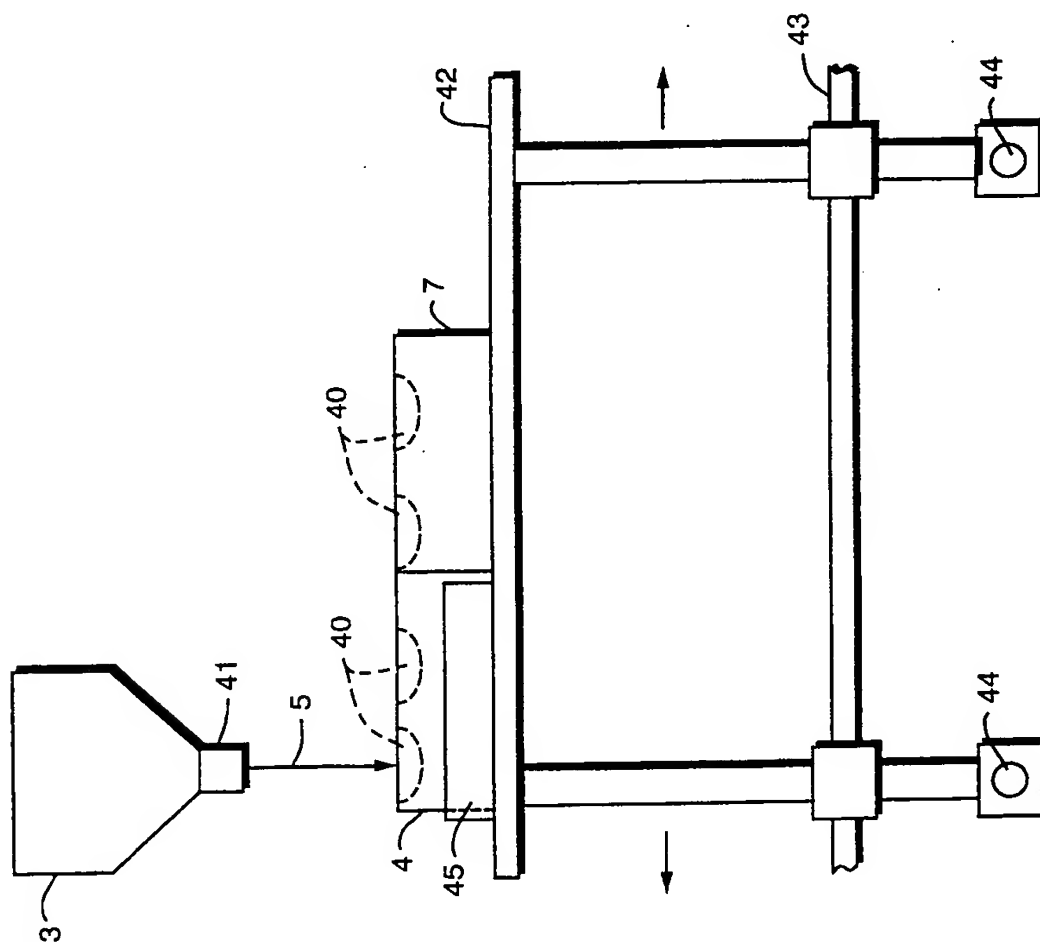


FIG. 3G



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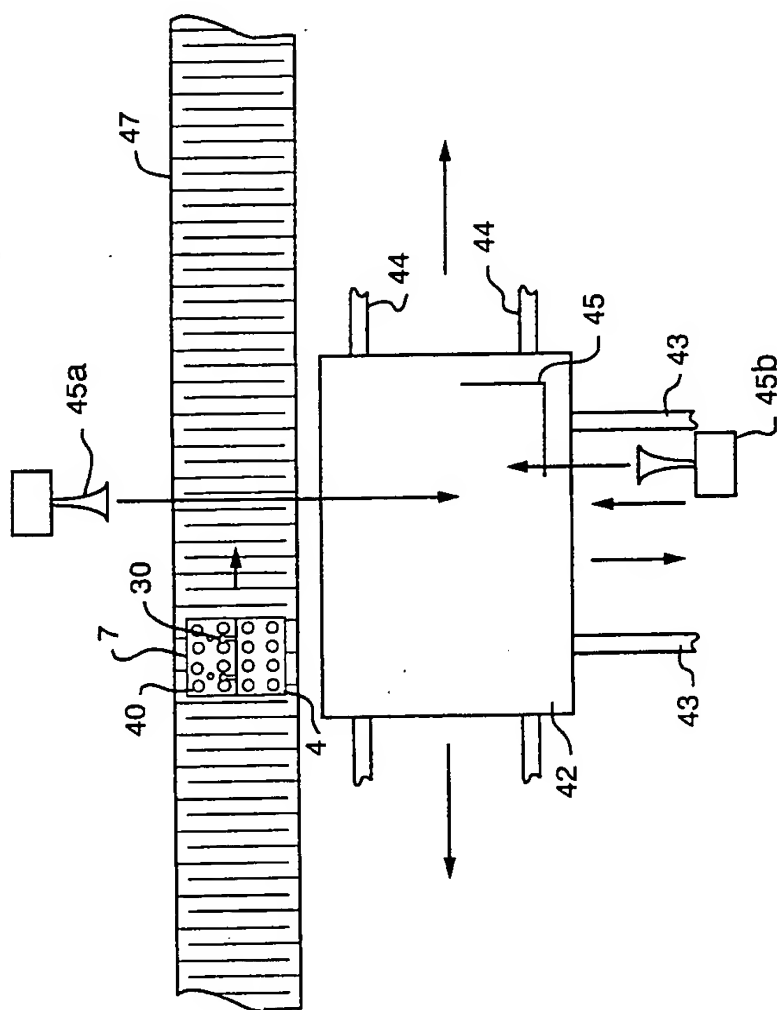


FIG. 3H

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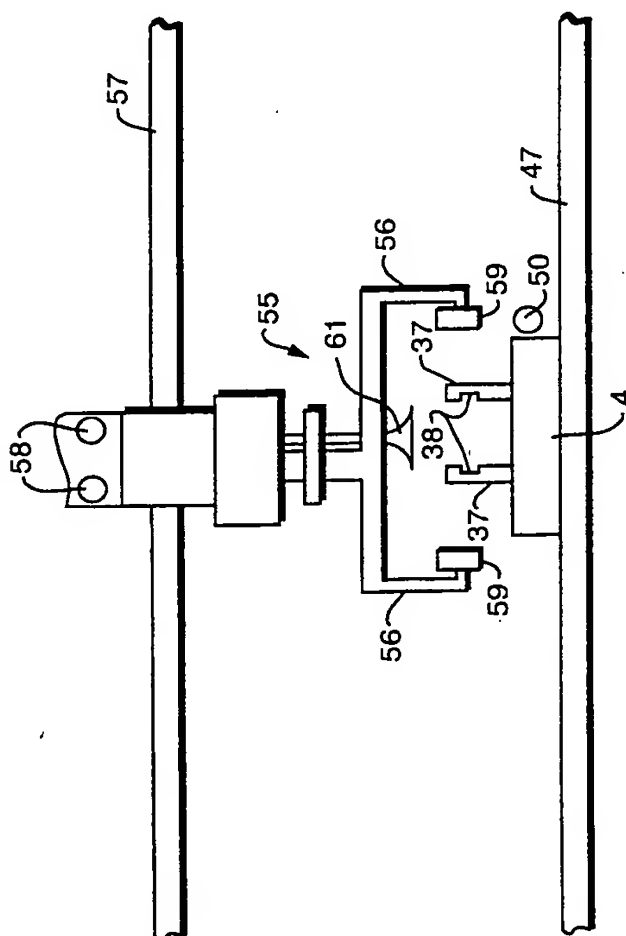
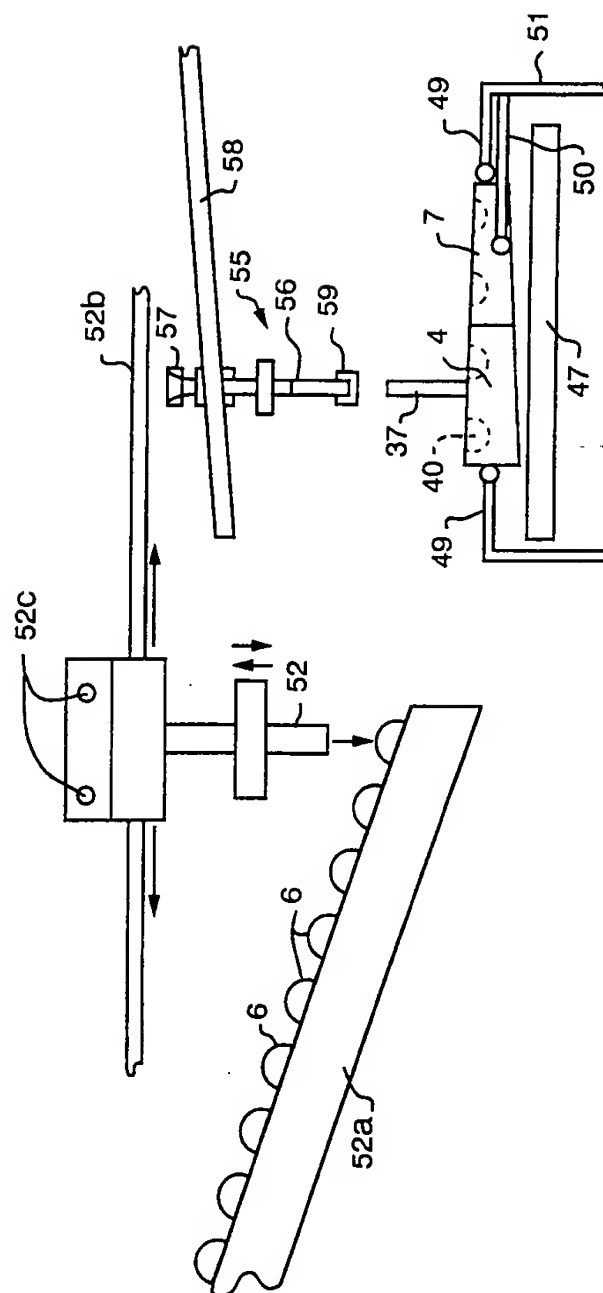


FIG. 3I

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**FIG. 3J**

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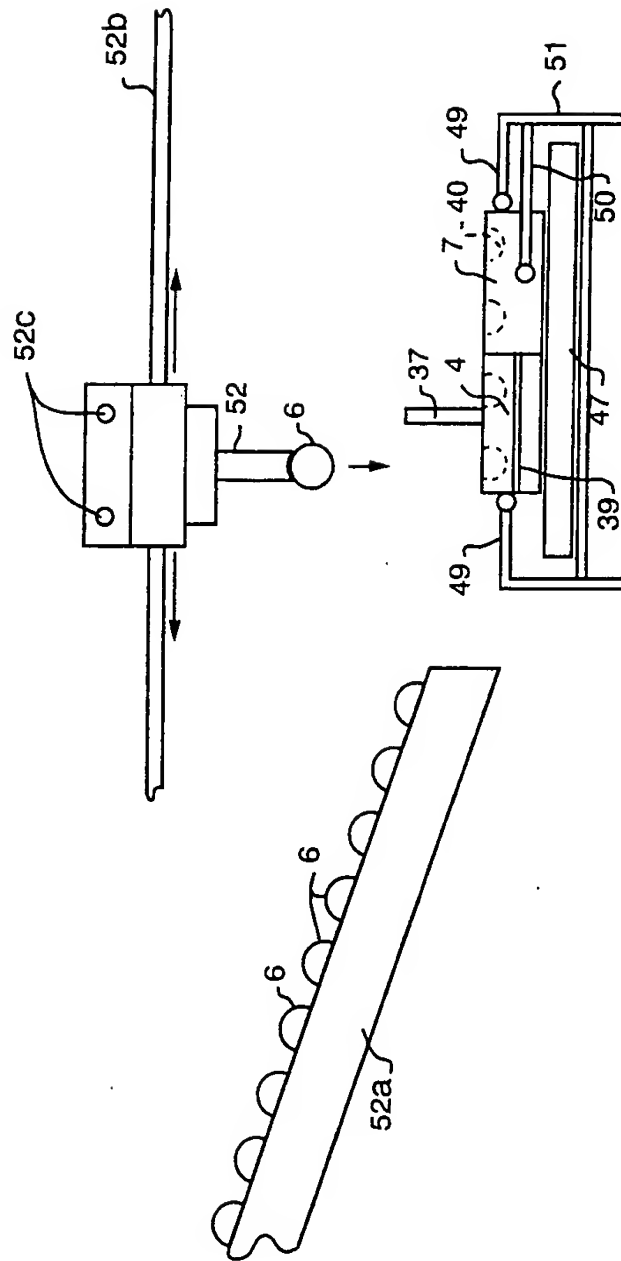


FIG. 3K

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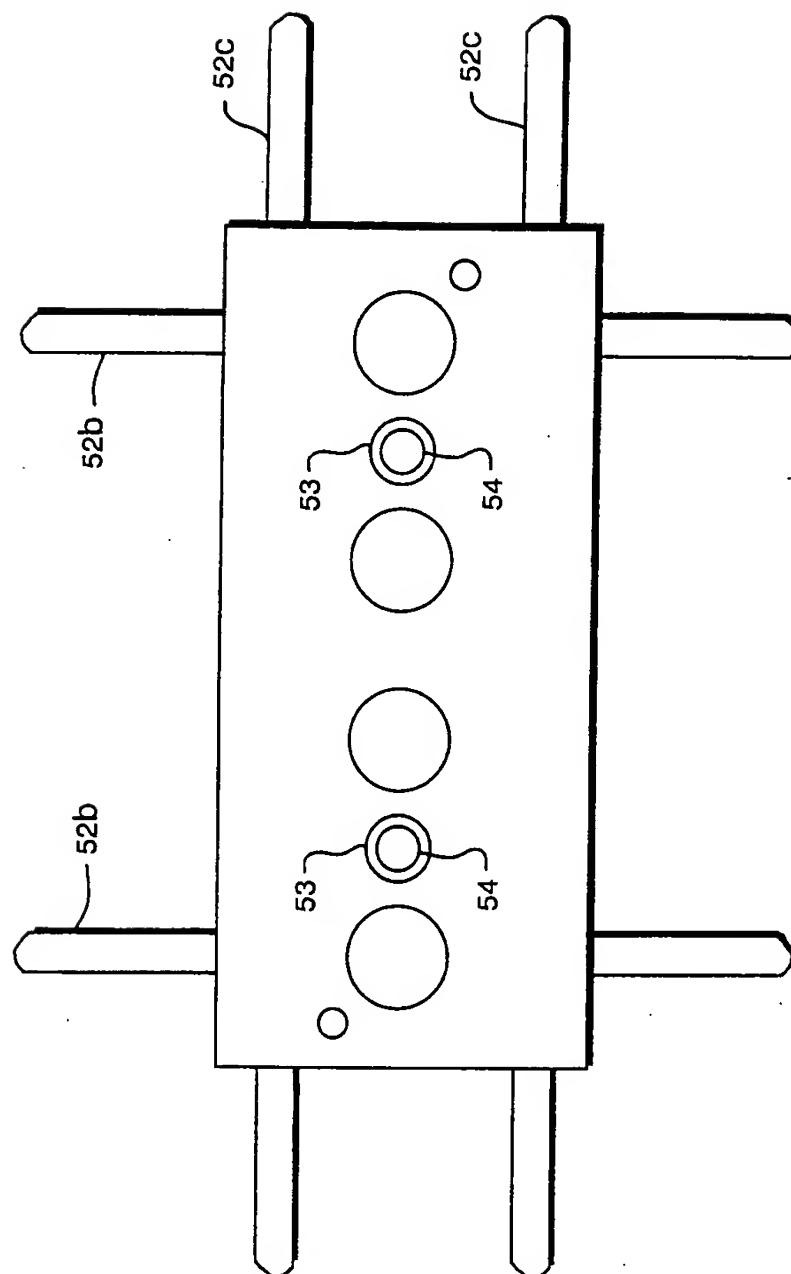


FIG. 3L

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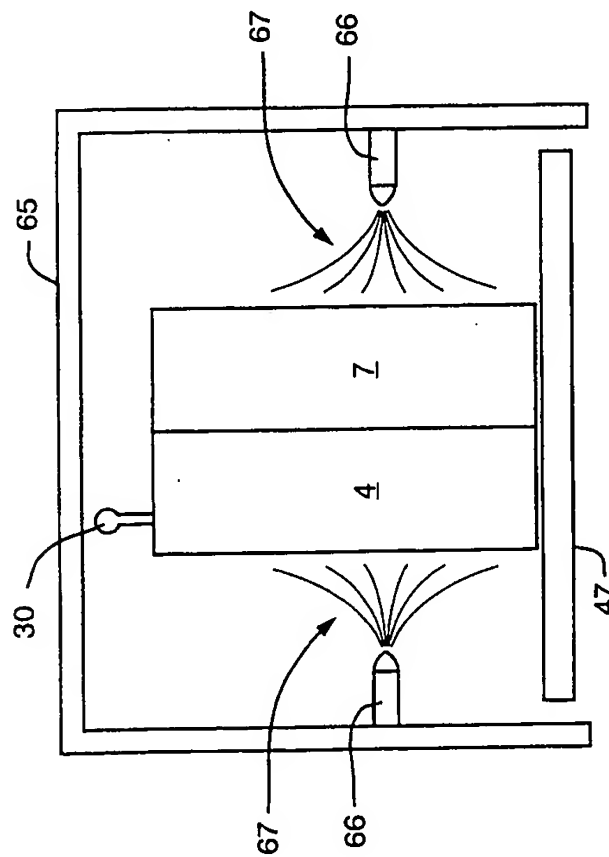


FIG. 3M

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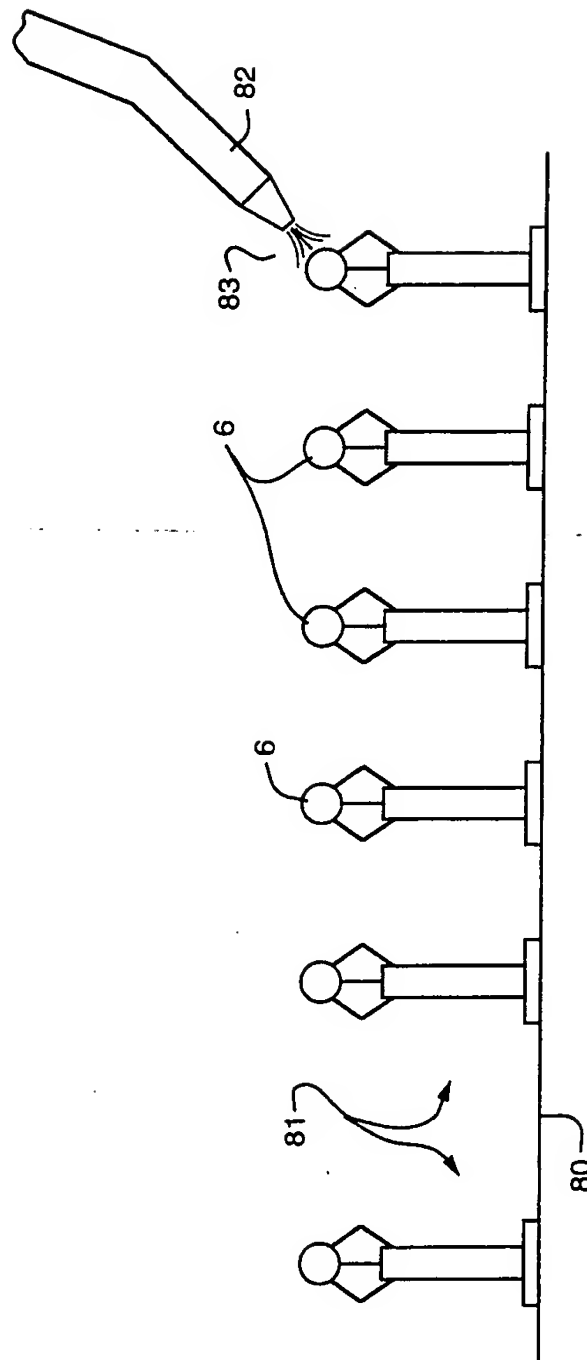
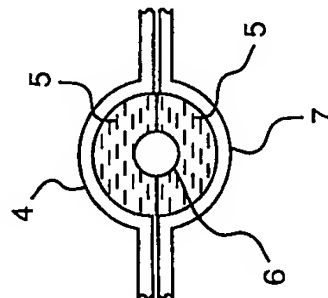
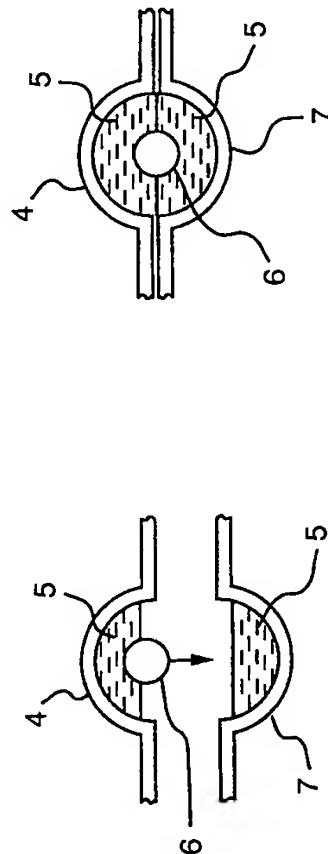
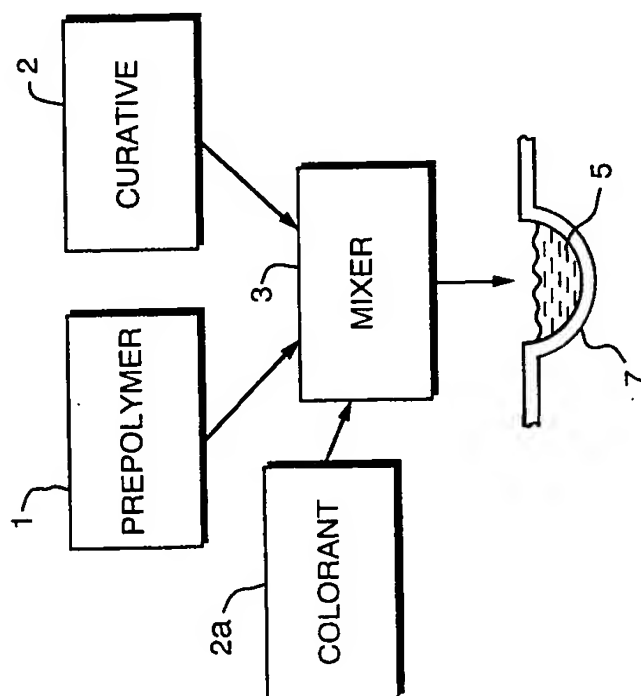
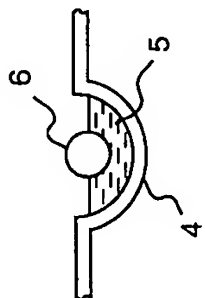
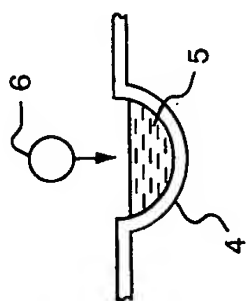
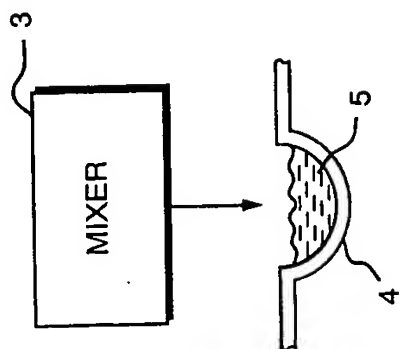


FIG. 3N





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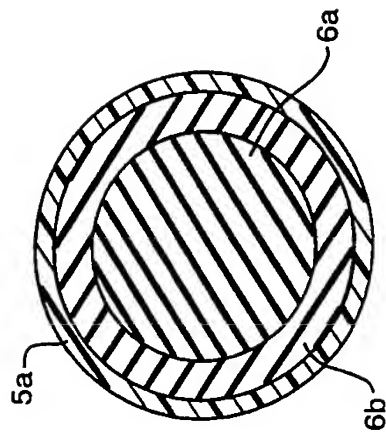


FIG. 11

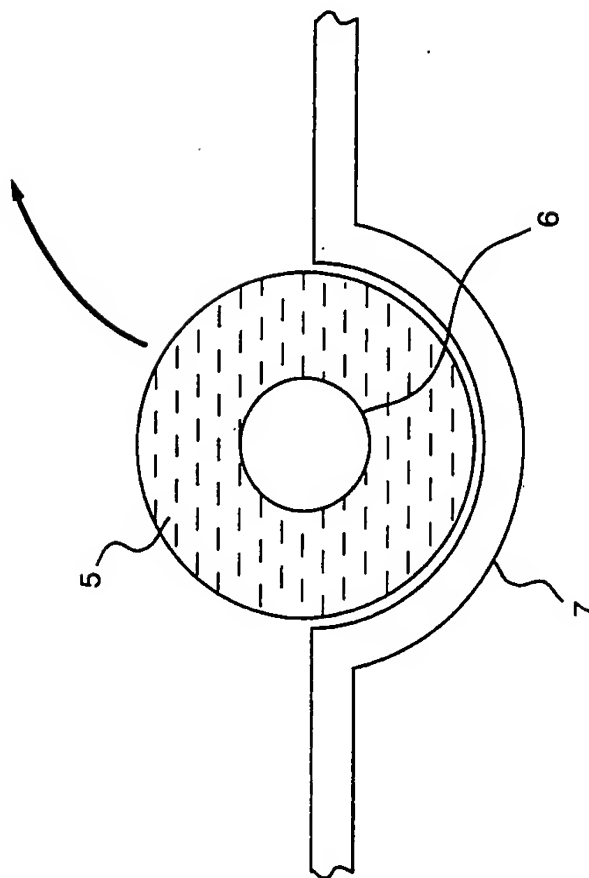


FIG. 10

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/04122

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 156/146; 264/259, 260, 271.1, 275, 277, 279, 279.1; 473/351, 356, 357, 365, 371, 377, 378; 528/61, 64, 67, 76

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,130,102 A (WATSON et al) 21 April 1964, column 1, lines 54-72, columns 2 and 3.	10-18, 46-57
Y	US 3,147,324 A (WARD) 01 September 1964, figures and columns 3 and 4.	10-18, 46-57
Y	US 3,177,280 A (FORD et al) 06 April 1965, column 2, lines 59-72, column 3, lines 1-19.	10-18, 46-57
Y	US 3,989,568 A (ISAAC) 02 November 1976, abstract, columns 2 and 3, and example 2.	1-57
Y	US 4,631,298 A (PRESSWOOD) 23 December 1986, columns 2-4.	1-9, 19-45
Y	US 5,334,673 A (WU) 02 August 1994, column 2.	1-9, 19-45

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*B* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*A* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

24 APRIL 1999

Date of mailing of the international search report

25 MAY 1999

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231  
Facsimile No. (703) 305-3230Authorized officer  
Rabon Sergeant

Telephone No. (703) 308-0661

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/04122

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,704,852 A (KATO et al) 06 January 1998, columns 2-5 and tables.	19-45
Y	GB 2,301,291 A (BRIDGESTONE SPORTS CO LTD) 12 April 1996, pages 7-9 and examples.	19-45

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US99/04122

**A. CLASSIFICATION OF SUBJECT MATTER:**

IPC (6):

A63B 37/02, 37/06, 37/12; B29C 39/18, 41/20, 43/18, 70/70; C08G 18/10, 18/32, 18/48

**A. CLASSIFICATION OF SUBJECT MATTER:**

US CL :

156/146; 264/259, 260, 271.1, 275, 277, 279, 279.1; 473/351, 356, 357, 365, 371, 377, 378; 528/61, 64, 67, 76